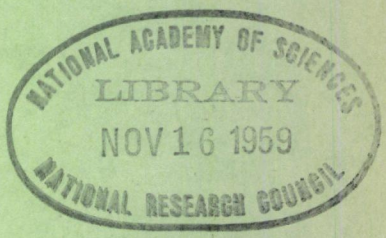
HIGHWAY RESEARCH BOARD

Bulletin 227

Highways and Economic Development



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Contents

Changes in Land Use and Value Along Atlanta's Expressways

J. H. LEMLY, Chairman, Department of Transportation and Public Utilities, Georgia State College of Business Administration, Atlanta

●ATLANTA'S SYSTEM of expressways has been under development for about eleven years. The highly important north-south portion of the system is well on the way to completion, the major east-west line is under construction, and an outer perimeter route is being developed on a section by section basis. The north-south connector in the center of the city is still incomplete, but many miles of high volume limited access roadways serve motorists in both the northern and southern segments of the metropolitan area.

There is widespread interest in the changes which may take place in urban development as a result of expressway development. In order to provide some specific local information, it was decided in June of 1957 to conduct a study to determine, insofar as possible, the effects of such construction on land use and value in the vicinity of the Atlanta Expressway.

Prior to the design of the Atlanta Expressway System, the State Highway Department, supported by the Bureau of Public Roads, made extensive studies to determine the desires and intentions of prospective users of the new facilities. The tests and projections showed that a large majority of vehicles on the expressways would be destined to go into the Atlanta area. For this reason, the north-south core of the Atlanta Expressway System was designed primarily to meet the needs of the metropolitan area rather than to act as a bypass route to take highway through-traffic away from the city. As a result, the Northwest and Northeast Expressways were engineered to converge at Brookwood Station to form a single route, the North Expressway, into the center of the city.

It might simplify understanding if these units are thought of as a giant letter Y, with the bottom of the letter thrusting into the north portion of Atlanta's central business district.

The North Expressway, which is the pillar of the Y, was intended to serve as a high-volume thoroughfare and was expected to remove a major portion of the traffic flow from overworked streets nearby. A large amount of traffic has shifted to the North Expressway, but because of the general increase in traffic flow in the entire metropolitan area the current volume along Spring and West Peachtree is approximately equal to that which existed previously.

The Northeast Expressway was planned as a new road to serve the mid-northeast sector of the metropolitan area. It also was expected to relieve local traffic congestion, principally on Peachtree and Piedmont Roads. Movement along the Northeast Expressway is heavier than was contemplated at the time of development, and the other important thoroughfares serving this region also carry maximum numbers of vehicles.

An important result of the community planning which brought about the development of the expressway system was the location finally chosen for the rights-of-way. The objective was to build the expressways in areas where they would best serve the community, but at the same time, vacant or low value areas were chosen whenever this was possible. The route designated for the North Expressway ran through a partially vacant area adjoined by low value properties; along the Northeast Expressway, large tracts of vacant land existed on both sides of the right-of-way. The choice of these sites indicated that extensive changes in land use and value in adjacent properties should be expected to follow in the wake of construction.

AREA STUDIED

Studies of this type are always troubled by the problem of defining an area to be examined because there is no exact way to measure roadway influence upon any given

piece of property, especially when the property does not front on and have direct access to the roadway in question. In the Atlanta study it was decided to use the oldest portion of the expressway system which fortunately served a broad accumulation of commercial and industrial properties as well as urban and suburban residential sectors. A relatively large tract of land in the north and northeast part of the metropolitan area of Atlanta was thus selected as the study area. It begins at North Avenue (US 78) near the central business district, extends north along the North Expressway to the Brookwood Station interchange, and thence runs out along the Northeast Expressway to Clairmont Road.

There are eight interchanges and two street grade separations serving the 7 ½-mi area. Three of the interchanges and one grade separation are found south of the Brookwood Station interchange. The three interchanges along the Northeast Expressway out to Clairmont Road are of similar design but are more widely separated. Each interchange or separation provides passage of its intersecting main artery across the expressway. All other roads and streets formerly crossing the line now occupied by the expressway have either been closed or diverted away.

PATTERN FOR THE STUDY

Changes in land value have been studied by means of comparison.

Changes in land value during the period of the study were obtained by a study of prices paid for properties within the study area. All real property sales were obtained by examination of deed records and appropriate values for the land without buildings were developed. These values then were available for comparison with other properties.

Areas affected by expressway development have been compared with unaffected or "control" areas, both before and after construction of the expressway.

Anyone familiar with real estate markets understands that no two urban properties can be identical. Similar houses and buildings can be constructed if this is desired, but every piece of land has a certain amount of monopoly value. No two lots can occupy the same location, and location is one of the prime factors in determining land value.

For this and other reasons, no area is available to serve as a perfect basis of com-

Figure 1. Atlanta, looking southeast, with Tech Stadium in middle distance at right. North Avenue, crossing Expressway to left of Stadium is beginning of study area. North-South Expressway extends north (left) out of picture at lower left.

Figure 2. Downtown Atlanta, looking in opposite direction to Figure 1, with Expressway in upper middle. Tech Stadium and North Avenue bridge are near southern end of Expressway, which extends out of picture at top.

parison for this study. Since the comparative method is desirable, however, an area was designated which has many of the characteristics of the study area. This sector is generally of the same type and nature as that in the northeast section except that no expressway construction has taken place nor is any planned for this region. The control area, located in four and one-half land lots in southwest Atlanta, includes commercial property, churches, schools, apartment houses, and residences.

Two major road systems serve the control area and provide access to the central business district. They are (a) Cascade-Gordon-Peters Streets and (b) Campbellton-Lee-Peters Streets. Both road systems come together south of the central business district, but there are alternate routes into the city. Although the route into the central business district is occupied by older commercial establishments, the traffic pattern is comparable to that of the study area before the development of the north and northeast expressways.

The control area has a mixture of older, well-established sectors and some that have been developed during the years covered by the study. New desirable subdivisions and shopping centers have been opened in the control area in a manner similar to that in the study area, but there has been no industrial development.

Also, affected areas of one type have been compared with affected areas of other types in an effort to determine the degree of influence and the timing of influence of expressway construction.

Changes in land use also have been studied by means of comparison, except that control areas have not been used as a major technique. Before-and-after comparisons as well as comparisons of different sectors of the study area have been the principal tools of analysis. In addition, extensive compilations of information pertaining to the total extent of change in land use have been developed.

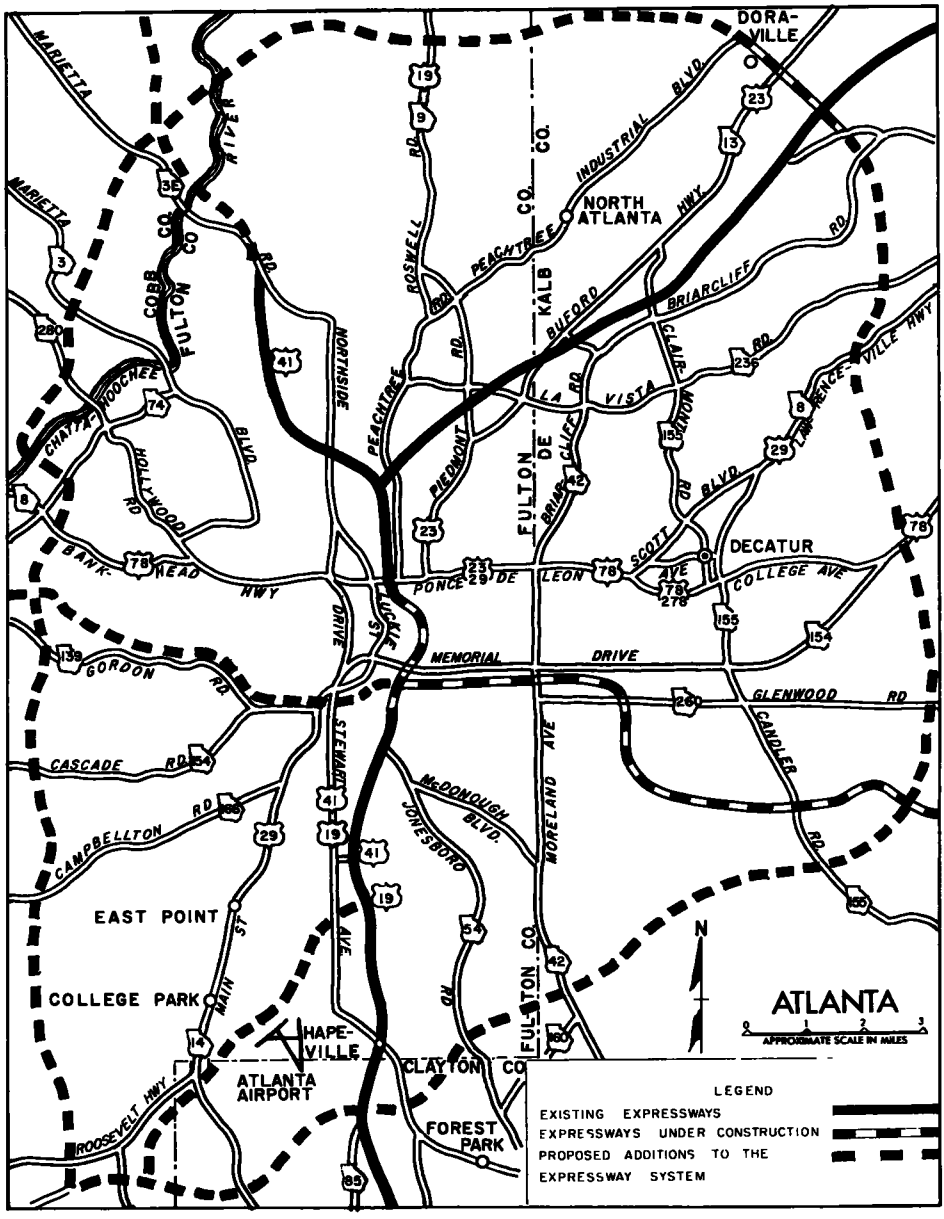

Figure 3. Atlanta's expressway system.

The plan for observing changes in land values and land use was to compare or contrast changes in certain areas as conditions changed over time. This necessitated the establishment of time periods divided as nearly as possible into equal lengths, both before and after construction, in order to measure changes caused or influenced by the coming of the expressway. The sixteen years from 1941 through 1956 were established as the study period. The years 1941 through 1946 (Period I) were taken as years before the expressway was built and before much serious thought was given to construction. The years 1947 through 1951 (Period II) cover the period of major study as well as construction of the first part of the expressway. The years 1952 through 1956 (Period III) constitute the period following early activity during which the northeast leg of the

expressway was completed. An ideal study situation would call for an additional time period, perhaps five years following the completion of the northeast section of the expressway. It would be highly proper and enlightening if such a study of a post-construction period were to be arranged at sometime in the future.

BASIC ASSUMPTIONS

Three assumptions stand out as basic to the procedure of this study. These assumptions underlie the division of the study area into band, section, and strip noted below.

Initially, it was assumed that there would be variations in land use and land value as the distance from the central business district increased. To study these variations, the subject area was divided into sections, which changed as distance from the central business district increased.

The purpose was to designate sections showing the relative nearness to downtown Atlanta. Thus, Section 1 is closest and Section 6 is the most distant. These divisions are not evenly spaced, but have been established in a manner designed to keep like properties in the same section whenever possible. As is true with the band designation, some section numbers have been omitted because of the shape of the study area; but in no case has a section number been misapplied so as to cause confusion about distance from downtown. Section 1 is composed of the area from North Avenue to Sixteenth Street, or that property closest to downtown Atlanta. Section 2 is composed of the properties located on both sides of Peachtree Road in the vicinity of Brookwood Station. Section 3 lies beyond this area and is roughly bounded by Piedmont and Cheshire Bridge Roads. Section 4 is marked by Lenox Road extending both north and south of the expressway. Section 5 is bounded on the east by a combination of Briarcliff and North Druid Hills Road running roughly north and south through the study area. Section 6 is bounded on the east by Clairmont Road and the boundary of the study area in the northeast sector.

Figure 4. Aerial view looking north, showing boundaries of study area.

Second, it was assumed that variations in land use and land value would occur as the distance from the expressway right-of-way increased. In order to measure changes of this kind, the study area was divided into bands which changed as distance from the expressway increased.

This breakdown of the area serves to establish bands paralleling the expressway to distinguish nearness to the expressway. Band A thus is closest to the roadway, Band B is next, and Band C is the area most distant from the right-of-way. The bands are not of equal width throughout their length, because an effort was made to keep like properties in the same band whenever this was possible. In a few cases, because of special

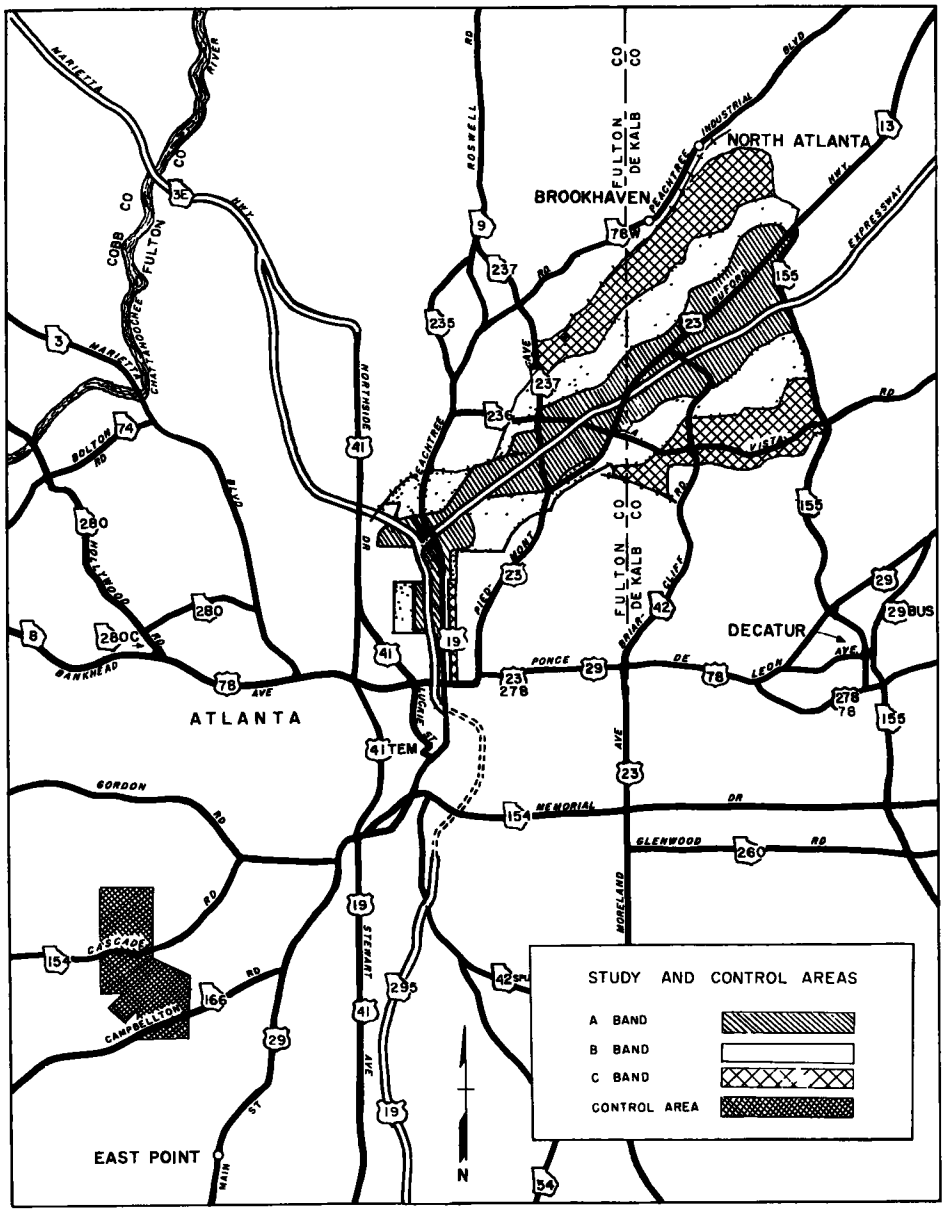

Figure 5.

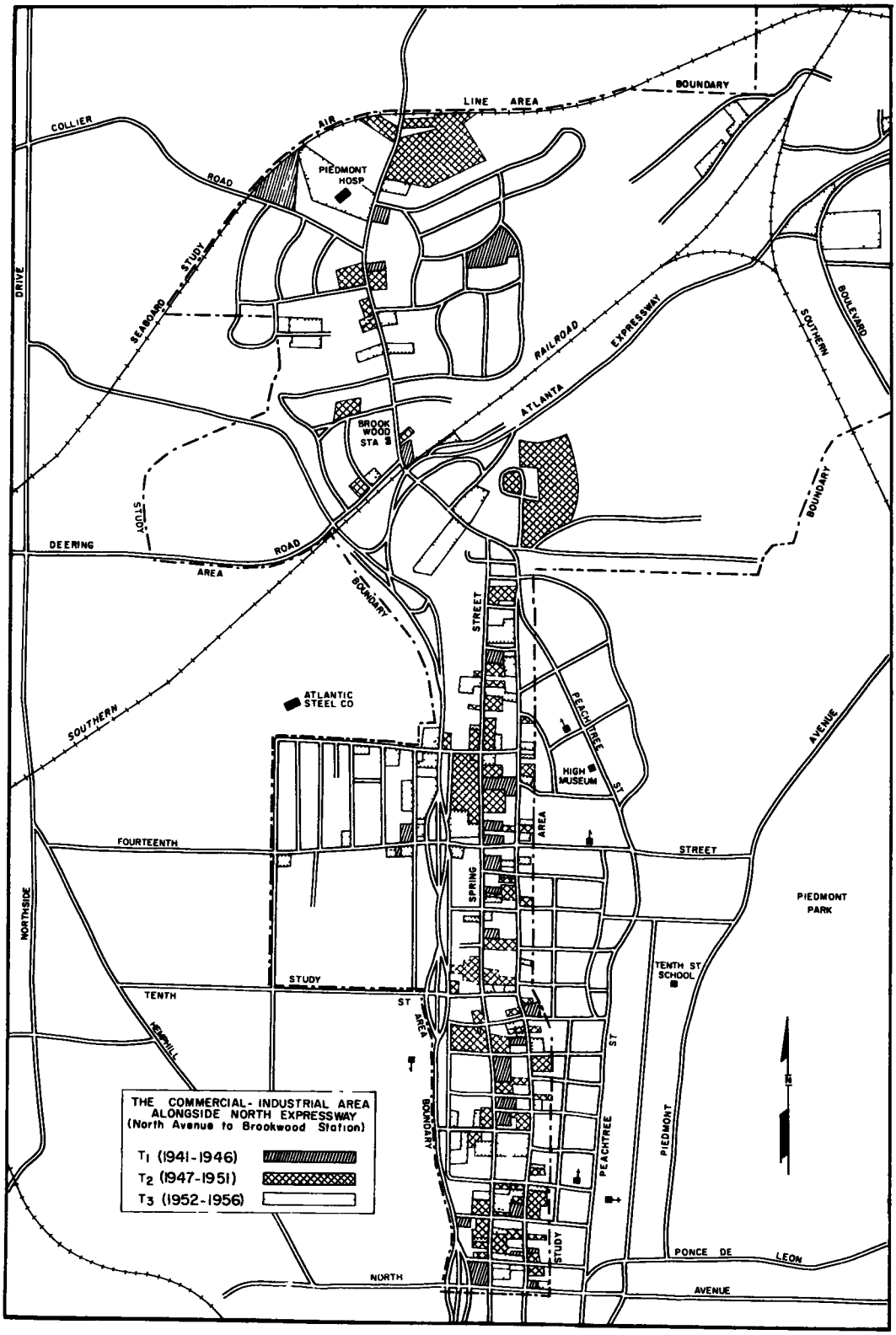
COLLIER ROAD
AIR LINE AREA
BOUNDARY
PIEDMONT HOSP
SEABOARD STUDY
DRIVE
RAILROAD
ATLANTA EXPRESSWAY
SOUTHERN BOULEVARD
BROOK WOOD STA
STUDY
DEERING ROAD
AREA
BOUNDARY
STREET
ATLANTIC STEEL CO
SOUTHERN
PEACHTREE ST
HIGH MUSEUM
AVENUE
FOURTEENTH
STREET
AREA
SPRING
NORTHSIDE
PIEDMONT PARK
TENTH ST SCHOOL
STUDY
TENTH
ST
AREA
BOUNDARY
PEACHTREE ST
PIEDMONT
STUDY
PONCE DE LEON
NORTH
AVENUE
THE COMMERCIAL- INDUSTRIAL AREA ALONGSIDE NORTH EXPRESSWAY
(North Avenue to Brookwood Station)
T1 (1941-1946)
T2 (1947-1951)
T3 (1952-1956)

Figure 6.

problems of development or size in the area, a band designation has been altered in an effort to preserve as much homogeneity as possible.

Third, it was assumed that changes in accessibility would cause variations in land use and land value within the central business district and along the more important access roads leading on and off the expressway. In order to show the changes in these areas, the downtown property fronting on Techwood, Williams, Spring and West Peachtree Streets as well as the major streets which cross the expressway (strips) have been treated separately.

The strips are made up of the properties that front upon and extend along both sides of the major roads crossing the expressway throughout the study area. For example, Fifth Street is Strip 1; Tenth Street, Strip 2; Fourteenth Street, Strip 3. Peachtree Road within the study area constitutes Strip 4. Strip 5 is that portion of Piedmont Road south of the Southern Railway line lying within the study area. Strip 6 is Cheshire Bridge Road between the expressway and Piedmont Road. Strip 7 is all of the Buford Highway lying within the study area.

In addition to the separation into sections, bands, and strips, the study area also was divided into sides of the expressway and a separation by counties was necessary for collection purposes. There was no other purpose in separating the material into Fulton and DeKalb County groupings as no natural barrier exists at the county line.

Figure 7. North Expressway and cross streets (strips). Two of the streets (strips 6 and 7) are off the picture.

EVIDENCES OF CHANGE

The plan for measuring specific changes within the study area was built around the three basic assumptions just mentioned which are not applicable only in Atlanta but are more or less general in nature. The first assumption was based on the general tendency for land use and values in urban communities to decline as distance from the central business district increases.

A special feature related to distance from the central business district is a result of the geography of the study area. Due to the location of the expressway, all property on the east side of the study area is closer to the central business district than are the

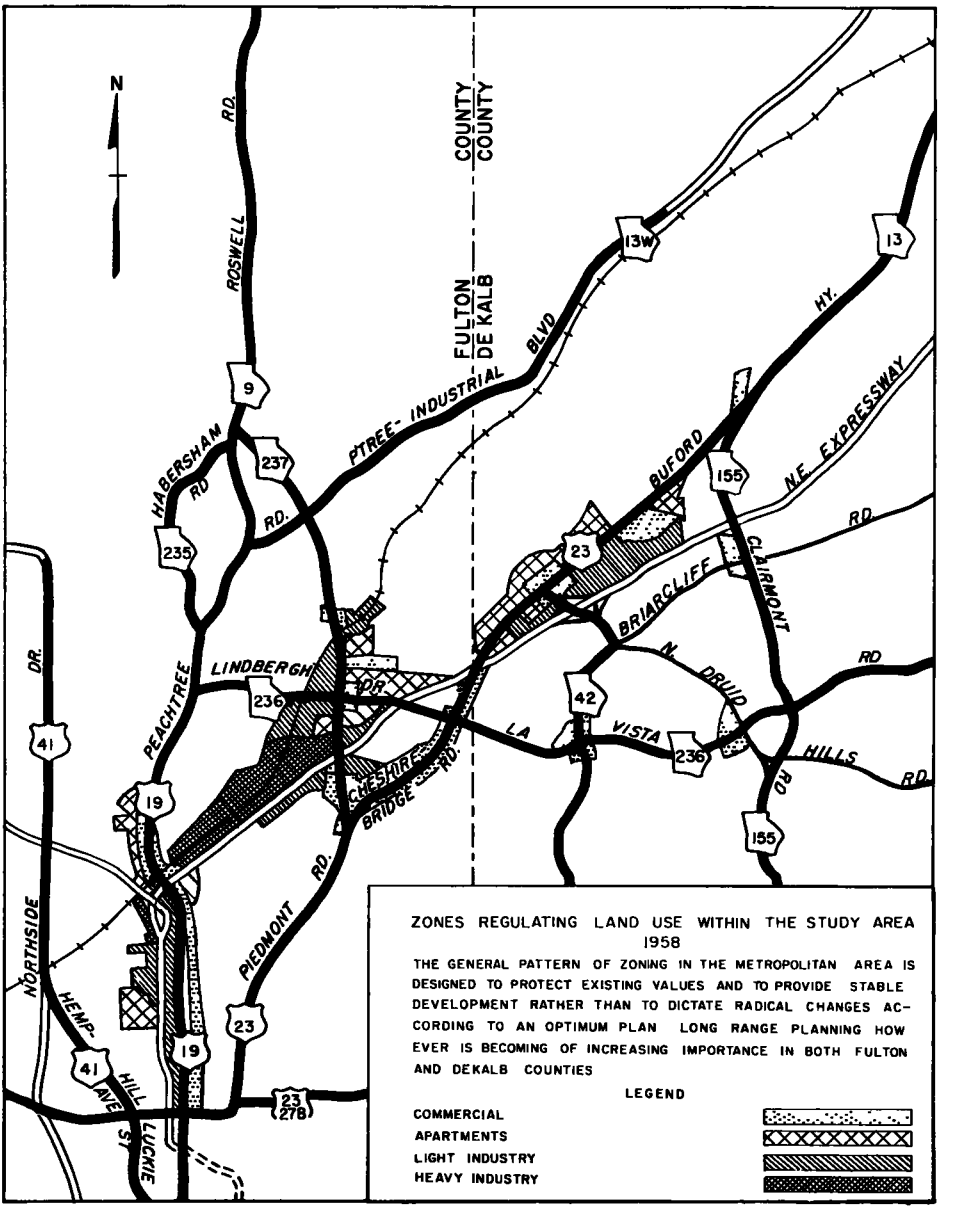

Figure 8. Zone areas within study sections and use for which each is designated.

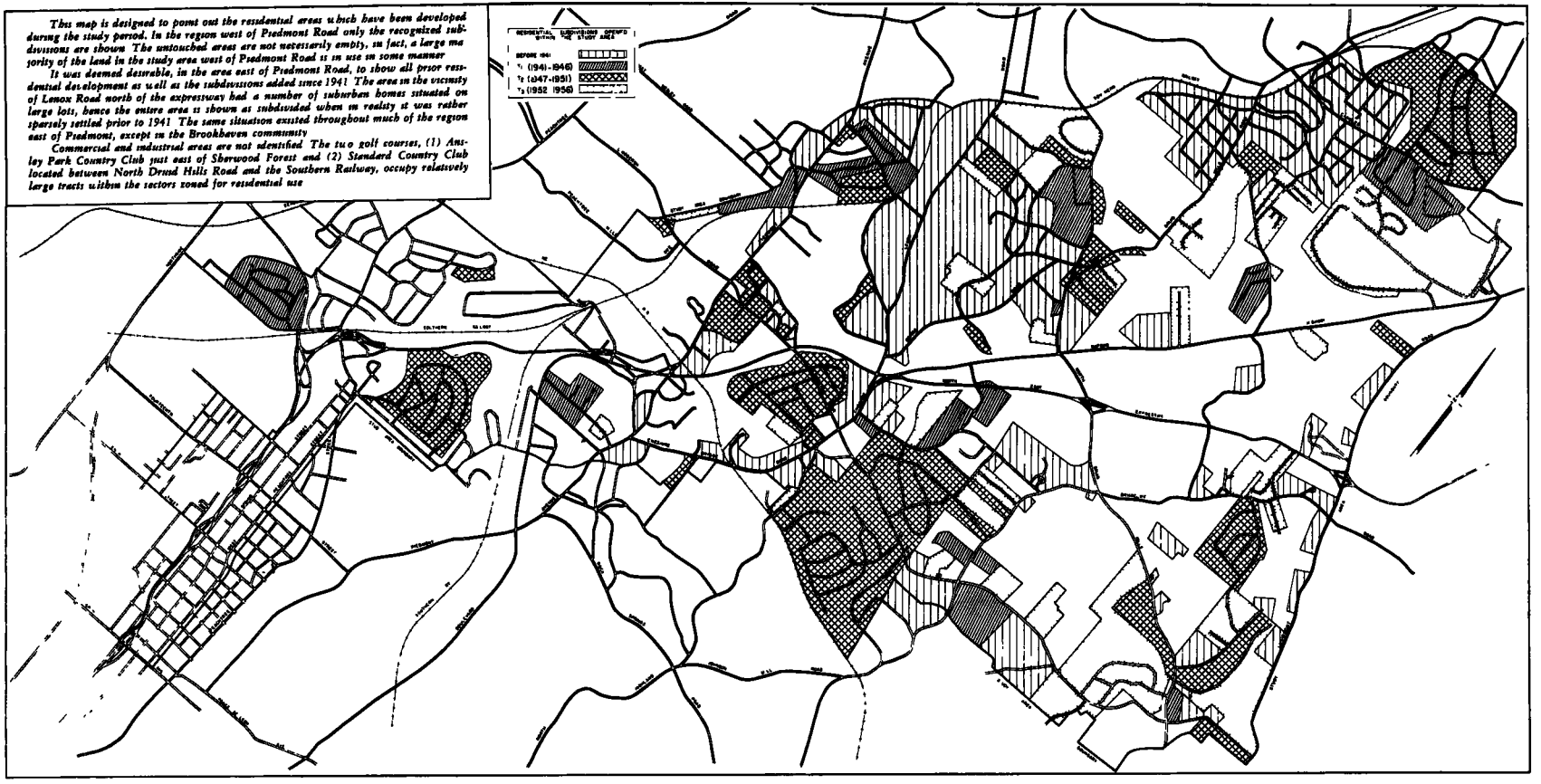

Figure 9. Residential subdivisions opened before 1941 and during the three time-periods of the study.

corresponding sections on the west side of the study area. This characteristic is a partial explanation of the fact that property values on the east side are consistently higher in value than those on the west. Several specific examples can be cited which emphasize this rather unusual phenomenon. First, the most important commercial areas within the entire study territory are found along Spring and West Peachtree Streets. Also the highest valued residential property in the study area is that in Sherwood Forest. In addition, up to the present time, more extensive commercial activity has taken place along Cheshire Bridge and along Piedmont Road south of the expressway. This may not hold true in future years when Piedmont north of the expressway is widened.

It was felt that the construction of the Atlanta expressway system might alter the existing pattern of urban land development within the areas influenced by these new roads. Examination of the evidence in this study has shown that within the designated areas the expressway has helped to produce such changes.

In Period I, land values did not decline uniformly as distance from the central bus-

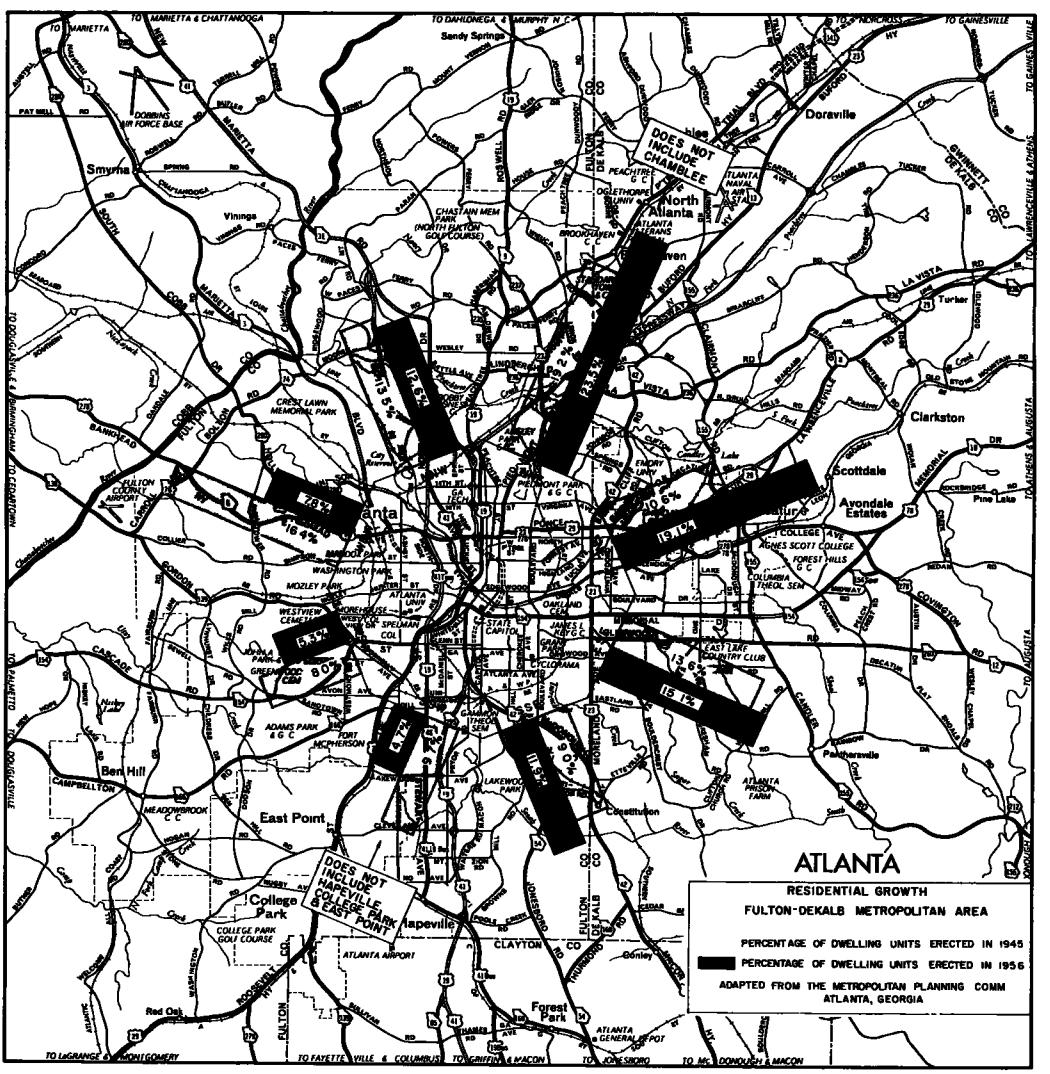

Figure 10. Relative percentages of residential growth in dwelling units and distribution over the Atlanta area by percentages in 1945 and in 1956.

iness district increased. It is true that typical declines were in evidence in some sectors but certain areas outside of the downtown sector were more valuable than other areas located closer to the central business district. On the east side of the study area in Band A, Section 4 had higher values than Section 3; and in Band B, Section 5 had higher values than Section 4. Also in Band B, Section 4 had higher values than Section 3. On the west side of the study area, within Band A, Section 4 was higher in value than Section 3 and Section 5 was higher in value than Section 4. Also on the west side, in Band B, Section 2 was higher in value than was Section 1.

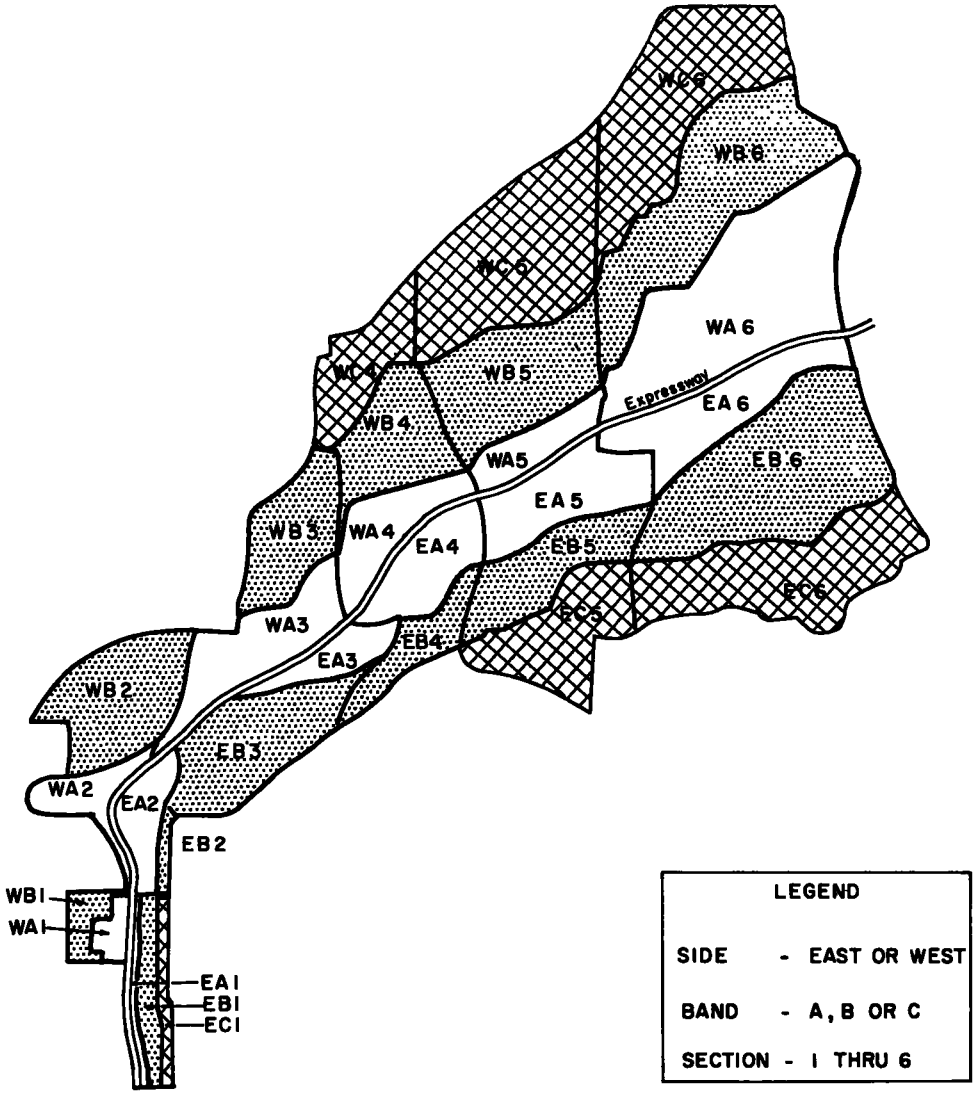

Figure 11. Study area by side, band, and section.

One apparent reason for these departures from the typical pattern of declining prices in relation to distance can be found in neighborhood characteristics such as the status of development at a given time. In some of these cases, vacant land was compared with developed land; this was true for Sections 3 and 4 in Band B on the east side. In other cases, comparisons between low priced residential areas and higher priced residential areas were being made.

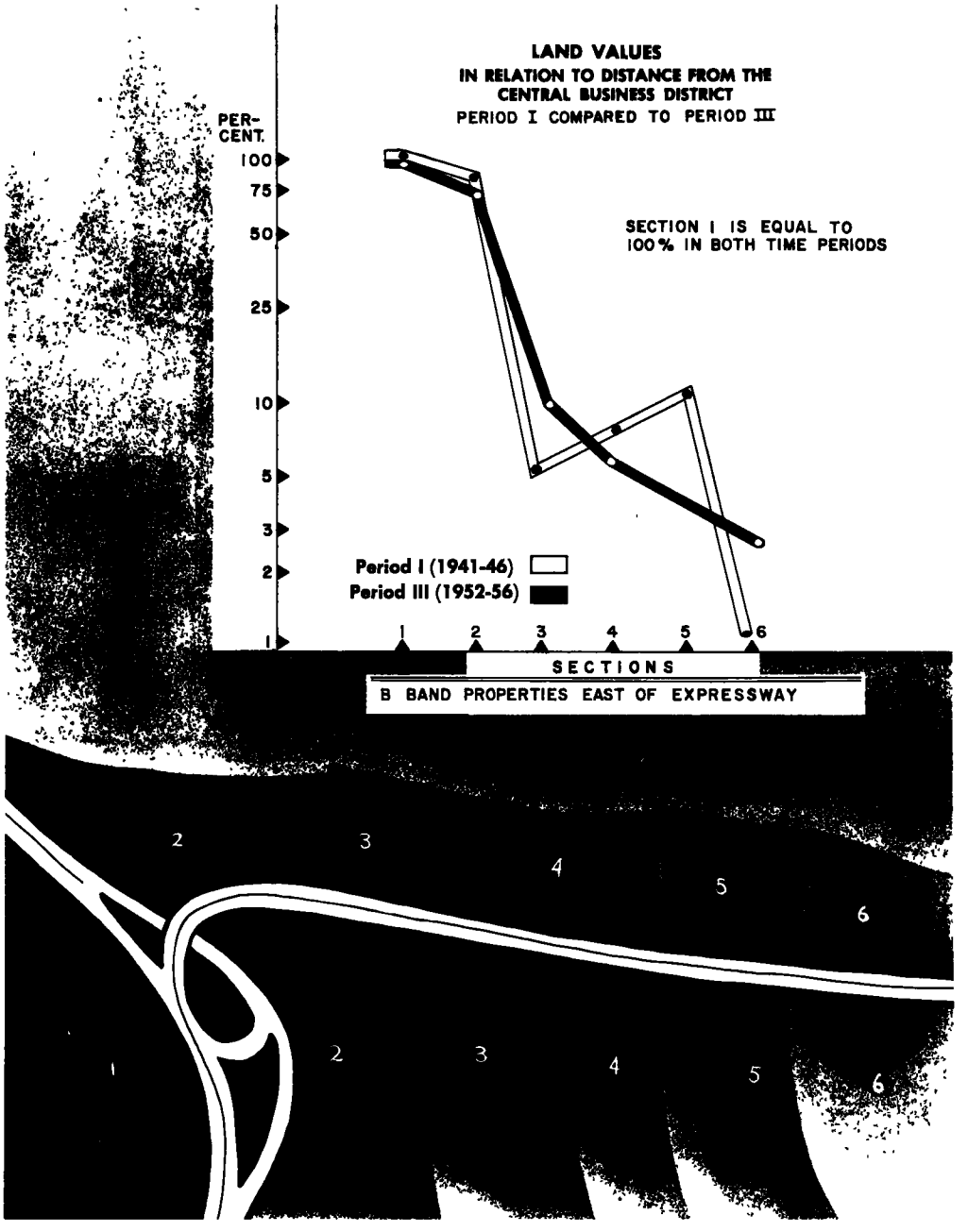

Figure 12. Changes in land values in relation to distance from central business district.

Another possible explanation for the existence of higher priced areas located farther from downtown than the lower priced areas is the tendency for new development to leap-frog over older regions which show signs of declining desirability. A clear example of bypassing in this manner is the comparison of Section 2 with Section 1, Band A, on the west side. Section 2 is much farther from the central business district and is relatively hard to reach from the downtown area. Section 1 is the older area developed many

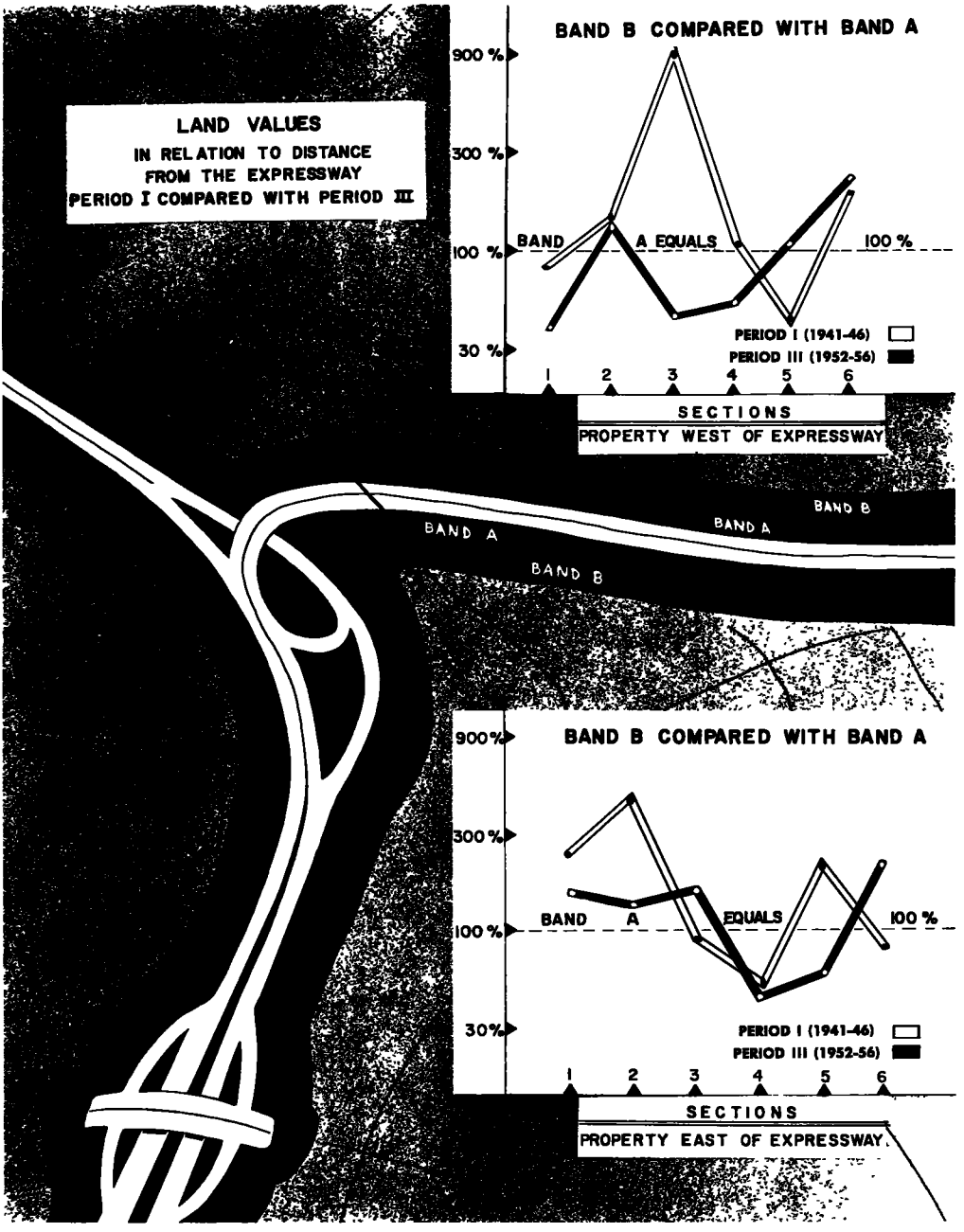

Figure 13. Changes in land values in relation to distance from Expressway.

years ago. Section 2 was opened for development during Period I and hence was at its peak in desirability. Also, these two areas are separated by the extensive property of the Atlantic Steel Company which provided a barrier to earlier extension in this sector. Section 2 values are not higher than those in Section 1 but they are considerably higher than one would expect under normal conditions.

Still another reason for the lack of uniformity in prices based on distance can be

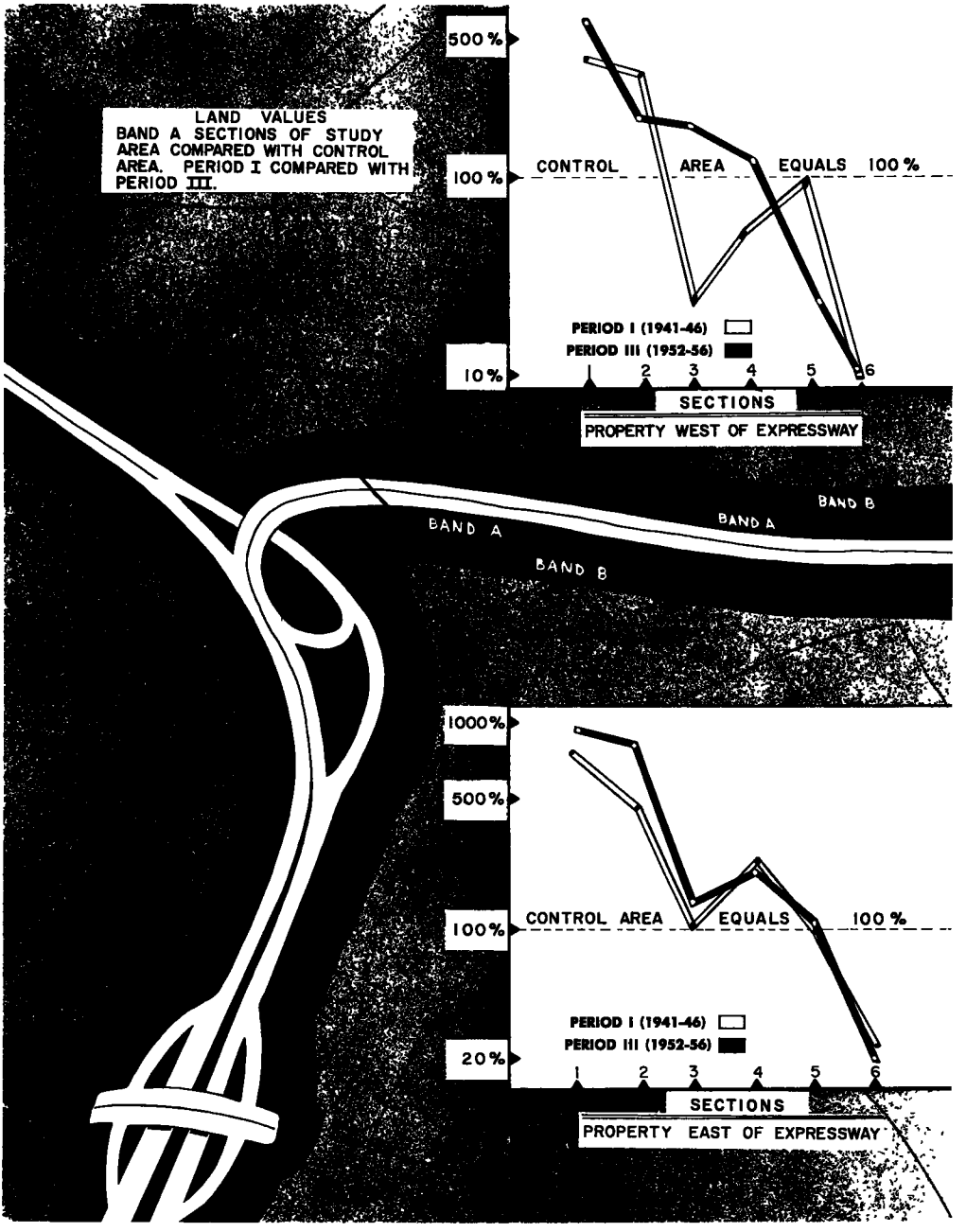

Figure 14. Changes in land values for Band A sections of study area as compared with control area.

found in street and terrain problems. This has been a highly important item because Atlanta has a very irregular street system caused largely by uneven terrain.

The coming of the expressway has altered the pattern of relationships which existed in Period I. In Period III, only two variations were in evidence and strong neighborhood influences prevailed in each case. On the east side of the expressway in Band A, Section 4 has higher values than does Section 3. This is a continuation of the pattern as found in Period I for these two neighborhoods. On the west side in Band B, Section 2 has values greater than Section 1. This also is a continuation of the situation existing in Period I. It should be stated that there is no similarity and little proximity between Sections 2 and 1 on the west side. The property of the Atlantic Steel Company as well as all of the properties in Section 2, Band A, intervene between the two sections. This separation was forced by the curve of the study area in the vicinity of Brookwood Station. Section 2, Band B, on the west side centers on Peachtree Road in a valuable area. Section 1, Band B, west side, consists of relatively small houses built many years ago in the vicinity south of the Atlantic Steel Company.

The second assumption pertains to variations in value in relation to lateral distance from the expressway. In Period I, Band A values were lower in general than were Band B values, and Band C values in general were higher than Band B. This is a relationship contrary to the theoretical assumptions that values are likely to decline with increases in lateral distance from the expressway. In Period I, however, no expressway existed and as has been pointed out, the rights-of-way were intentionally located in vacant property wherever possible. Hence in the Atlanta scene, it was entirely reasonable in Period I to find higher values at greater distances from the route selected for the Northeast Expressway. Certain exceptions to this over-all pattern existed in Period I and should be recognized here. On the east side, properties in Sections 3, 4 and 6 within Band A were greater than like sections in Band B; also, properties in Band C, Section 5 were drastically lower than Band B and lower than in Band A. On the west side, values of property in Band B in Sections 1 and 5 were lower than corresponding sections in Band A. Also in Section 5 on the west side, Band C was lower than Band A and Band C was greater than the properties in Band B in this section. These variations can be easily understood if an examination is made of neighborhood characteristics such as time of development, terrain features, or street layout in the subject areas. One specific case is cited here for illustration. In Period I, Section 3 in Band B, on the east side, was lower in value than in Band A. It should be remembered that Band B, Section 3, on the east side is largely made up of properties in Sherwood Forest. This land in Period I was raw land awaiting development. Section 3, Band A, on the contrary, had been extensively developed for some time prior to Period I.

In Period III, the evidence indicates that values in Bands B and C were still higher than values in Bands A, but the discrepancy was not nearly so great. Band A properties had increased much more rapidly on a relative basis. Again it is worthwhile to look at the exceptions in this analysis. In Period III on the east side, Sections 4 and 5 in Band B are less than in Band A. In Section 5 within Band C, property values are less than either A or B. On the west side, Sections 1, 3 and 4 are lower in value in Band B than in Band A. This represents no change for Section 1 but it does represent changes in Sections 3 and 4. Section 6 on the west side shows higher values in C than in B and higher values in B than in A, but Band A in this section has improved its position greatly in relation to Band C.

Clearly the evidence available at present indicates that the expressway has tended to increase values very substantially in Bands A. The total long-run evidence will not be available until a major portion of the land which is still vacant in Bands A is sold and put to urban uses.

The evidence is clear that the North Expressway has contributed materially to extensive changes in use within the area south of Brookwood Station. Changes in value have also been impressive in this area and the expressway has played a major part in these advances, particularly in the areas closest to the new roadway.

The second part of the third assumption concerns changes in land values along major streets crossing the expressway (strips). The changes in strip properties have been

compared with variations in neighboring land units. Over the 1941-1956 study span, Fifth, Tenth, Fourteenth, Peachtree and Cheshire Bridge Road properties advanced in value more rapidly than their neighborhoods. The highest rate of growth took place along Fifth Street and Cheshire Bridge Road. Fifth Street apparently felt the impact of the expanding business district and Cheshire Bridge Road shifted from mixed suburban usage to relatively high level commercial activity. The shift to industrial usage in the vicinity of Piedmont Road has brought wide-spread price increases in the surrounding region. Thus, while Piedmont Road properties have grown in value, they have not shown the rate of growth which has characterized the property along Cheshire Bridge Road.

All of the major traffic arteries which now cross the expressways were in existence before the building of the new roadways. Hence, it cannot be contended that any of them were created or made important solely by expressway construction. The evidence at hand, however, does indicate that the development of the expressway system has materially increased the rate of growth along these thoroughfares.

EFFECTS OF NEIGHBORHOOD DEVELOPMENT PATTERNS

Because of the importance of mobility in urban development, any expressway will make some contribution to greater use and higher values of properties within its tributary area. At the same time, however, it must be emphasized that a facility such as an expressway is only one determinant of value. The importance of an expressway in relation to other determinants such as shopping facilities, schools, churches, and prestige value, is variable. An expressway helps to provide a favorable climate but in a number of instances, local or neighborhood decisions have played a dominant part in establishing both use and value relationships within sectors. Analysis has indicated very clearly that the decisions made by land developers have been very important in establishing and maintaining high levels of use and value with specific neighborhoods.

RATES OF CHANGE IN LAND USE AND VALUE

One of the principal consequences of the development of the Northeast Expressway has been to open large amounts of land to new urban development. Not only has this roadway opened areas relatively close to the city but it is providing accessibility to a tremendous area which extends for many miles beyond Clairmont Road, the boundary for this present study. In providing these new areas for urban development, the expressway obviously has increased values in the areas thus made accessible. For example, in Period I, Section 6 was much lower in value than Sections 1 and 2. In Period III, Section 6 is still lower in value but its rate of growth has been more rapid than in the downtown sections. Without doubt, this is a result primarily of changing land use. Much of the land in Section 6 in Period I was raw land, but by Period III, residential development had taken up a major portion of the entire section. During the same period the downtown areas have not been static but the change from high level residential use to commercial activity has brought about a smaller percentage increase in value. Utilization in the downtown areas has been at a high level throughout the study period.

At the same time, a companion result of the expressway has been to weaken or reduce the rate of growth of property values in areas which formerly possessed local advantage due to the existing street and terrain pattern. The decline in relative value of Section 2, Band A, west side, is a clear example of this situation and others could be pointed out in other sectors, as can be seen from Table 1.

Three sections within the entire study area reveal declining prices from Period I to Period III. This evidence, is based on the constant dollar values used for all of the analytical material. In terms of current dollars, these declines disappear. It is true, however, that there are some sectors where evidences of growth in value are almost non-existent. In other areas the rate of growth in value has been little short of phenomenal. For example, Sections 1 and 3 in Band A on the east side have increased more than 200 percent in value while Section 2 has increased at a rate greater than 400 percent. Within Band B on the east side, Section 3 has increased by approximately 425 percent and Section 6 in the same period has increased by 485 percent. The only other

TABLE 1

RELATIVE CHANGE IN LAND VALUES, 1941-56

Side	Section	Relative Change[1] (%)								
		Periods I-II			Periods II-III			Periods I-III		
		Band A	Band B	Band C	Band A	Band B	Band C	Band A	Band B	Band C
East	1	24.1	48.2	NA	157.2	33.8	NA	219.2	98.3	93.0
	2	374.4	3.6	NA	8.3	61.5	NA	413.5	67.3	NA
	3	152.8	280.5	NA	19.8	32.2	NA	202.8	425.8	NA
	4	57.6	37.2	NA	32.3	21.2	NA	108.5	66.3	NA
	5	25.1	62.5-	125.9	104.2	110.8	329.8	155.5	20.9-	870.7
	6	37.3-	203.6	94.9	194.9	92.6	10.0	84.8	484.8	114.5
West	1	16.6	25.9	NA	187.7	29.1	NA	235.6	62.6	NA
	2	102.1	64.7	NA	18.9-	10.7-	NA	63.9	47.0	NA
	3	141.6	106.1	NA	754.7	50.1-	NA	1965.0	2.8	NA
	4	21.8	47.5	40.8	339.1	69.8	6.5-	435.0	150.5	31.6
	5	27.2	21.2	41.6	42.8-	44.9	43.7	27.2-	75.7	103.4
	6	150.0	693.1	16.8	17.6	56.1-	34.0	194.0	248.0	22.9-

[1] NA = Not applicable.

large-scale increase on the east side is Section 5 in Band C which has increased by 870 percent. The other sections on the east side have shown varying degrees of increase except Section 5, Band B, which shows approximately a 21 percent decline in value in constant dollars.

The areas listed are composed of a variety of activities. Sections 1 and 2, it will be recalled, are the downtown commercial areas. Section 3, Band A, is made up of commercial and industrial properties in the vicinity of the expressway south of Piedmont Road. Section 3, Band B, on the east side, is composed primarily of Sherwood Forest properties. Section 5, Band C, is land which in previous periods was isolated and almost ignored. In Section 6, Band B, properties consist of new and well accepted residential subdivisions.

There are not as many rapid increases in value on the west side as there are on the east, but the greatest single rate of increase for any sector is that for Section 3, Band A, on the west side. This section, composed almost entirely of industrial property, has increased almost 2,000 percent during the study period. At the time, Section 3 in Band B on the west side has shown an increase of only 3 percent for the same period. Much of the variation between these adjoining areas can be explained in neighborhood and time differentials.

Within Section 3, Band A has moved steadily toward high level industrial use from extremely low levels of use. It should be remembered that this area is bisected by tracks of both the Southern and Seaboard railroads as well as by Peachtree Creek. In former periods it was considered entirely unsuited to normal residential development. When the expressway provided access into this area, it immediately was marked for high level industrial expansion. The property in Band B presents a different picture. A substantial portion of the land in Section 3, Band B, is residential and was worth much more in Period I than the land in Band A. The rate of change in Band B during Periods I to II was almost as great as that for Band A. In Period III, sales of isolated, completely undeveloped tracts produced an average picture which is not representative.

Only two other sections on the west side have shown increases of more than 200 percent. Section I, Band A, on the west side has increased by approximately 236 percent, while Section 6, Band B, on the west side, has increased by 248 percent. Section 6, Band A, has done almost as well in increasing by 194 percent. Section 6 in Band C, however, shows a decline of almost 23 percent. This is perhaps the one area where

evidences of decline are strongest. Even here, however, current dollar prices do not indicate reductions but is true that the property has not kept pace with the Atlanta region as a whole. The other declining figure on the west side is for Section 5, Band A. It is not believed that actual declines exist in this area, but the design features of the expressway as well as relocation of traffic away from Buford Highway to the expressway has caused a lessening of desire for property in this immediate sector.

COMPARISON WITH CONTROL AREA

The last of the analytical patterns to be summarized is the comparison of sectors on the study area with the control area. The purpose of developing information about the control area was to determine, if possible, whether property within the study area had advanced more rapidly in value than had other sectors of the city. Average figures for each of the separate segments of the study area are compared with the average figures for the entire control area. Examination of the Period I price level for the control area alongside similar measurements for the various sectors within the study area reveals a wide range of differences.

When one tries to analyze the total relationship of the study area to the control area, no distinguishable pattern is apparent. Again it should be said that differences in neighborhood development account for most of the variations which exist. The study area, a large and diverse sector of the metropolitan region, contains a variety of neighborhoods with diverse patterns of land use and value. The control area, in contrast, is a much smaller and more unified sector which in Period I had little commercial activity. Its residential development had been uniformly superior to most of the other properties in its quardrant of the city, although it was not generally regarded as a "prestige" area by other sectors of the Atlanta community.

In Period III, a clearer picture has emerged. Both the control and the study area have undergone extensive development. Important commercial activity has sprung up in the control area and much residential building has taken place. The control area does not contain a burgeoning offshoot of the central business district and it does not have any industrial development inside its boundaries but without doubt its growth has kept pace with the community as a whole. Examination of the evidence shows that the rate of growth of values in the control area is greater than for a majority of the sections of the study area, but, taken as a whole, the study area has had a higher rate of growth than the control area.

It is felt that the more rapid growth of the total study area has resulted from the availability of special advantages in the region, one of which has been the expressway system.

CONCLUSIONS

This study has provided extensive information about the impact of the North and Northeast Expressways upon the areas served by these new roadways. The following are the broad accomplishments which can be credited to this major realignment of Atlanta's street system.

1. Commercial activity along the major thoroughfares crossing the expressway has increased greatly. Primary cause of this growth is the increased importance of these streets as a result of cross-town traffic being channeled over them.
2. South of Brookwood Station, (the downtown sector) a rapid change from residential to commercial and light industrial activity has been extensively influenced by the presence of the North Expressway. Properties in this area which were originally low in value have increased tremendously while the other higher valued properties have also increased as higher levels of use have been reached or changes to new uses have been made.
3. A large majority of all land close to the expressway lying east of Brookwood Station (Peachtree Road) and west of Piedmont Road has been devoted to or zoned for industrial use. In these areas the rate of increase in value has been remarkable. In particular, the value of vacant land in this area has undergone tremendous increases.

The Northeast Expressway has been the factor which has brought these areas into prominence although other items such as proximity to the center of the city and the presence of rail facilities have played an important part in the development of these areas.

A major portion of the land lying east of Piedmont Road and immediately adjacent to the Northeast Expressway has been devoted to or zoned for industrial expansion. Little of the land within DeKalb County which is zoned for industrial uses has been sold. For this reason no specific measures of the final acceptance of these areas can be obtained at this time. It is felt that the industrial areas east of the Cheshire Bridge-Buford Highway intersection with the expressway will owe much of whatever improvement they receive to the presence of the Northeast Expressway. Prior to the coming of the expressway, this area had little or no reason to expect serious industrial development as it is far removed from the center of the city and has no peculiar advantage to assist its industrial development.

4. Because of the rate of commercial and industrial expansion, in a relatively short period of time no residential properties will remain in the region east of Techwood and south of Brookwood Station. The residential areas just north of Brookwood are being influenced and altered but the expressway system is only indirectly involved in these changes.

Two new residential areas, Sherwood Forest and the Martin Manor-Lindridge sector, have been very well received by the general public and show no injurious effects resulting from location immediately adjacent to the expressway. Other residential areas close to the route of the Northeast Expressway have not been injured and in some cases new activity is superior to the older development in these sectors.

East of Piedmont Road, a majority of all land within the study area is devoted to or zoned for residential use. High levels of activity have been observed in this area during the years that the Northeast Expressway was being planned and built. Extensive changes have taken place in values of land in this area, with some neighborhoods showing weak tendencies of growth and with others showing tremendous improvements in use and value.

The effect of the Northeast Expressway does not halt at the eastern boundary of the present study area. Impressive developments are continuing for several miles east of Clairmont Road within the area tributary to the Northeast Expressway. In general, a higher level of residential development is being maintained in the larger, newer, tracts located at some distance from the expressway route.

Multi-unit apartment development within the study area has not been significant except in the sector west of Peachtree Road. Outside of this sector, almost all of the units which have been built within the study area are in the immediate vicinity of or east of Piedmont Road.

The economic impact of the North and Northeast Expressways upon the areas tributary to these roads has been impressive up to the present time. It must be realized, however, that the full effect of expressway development cannot be measured at a time so soon after construction. For that reason, the results presented in this report should be regarded as preliminary findings. A further analysis at a future time should yield definitive results.

Massachusetts Route 128 Impact Study

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This paper summarizes the major findings of the study, and analyzes the influence of the highway on adjacent land use. The impact of land use changes on the communities along the highway and on the metropolitan area also are explored. The effect on Route 128 of the traffic generated at new industrial plants is evaluated.

The methodology used in the study is critically examined and suggestions are made for improvements in impact study techniques, and for further areas of needed research.

● THE PURPOSE of the Massachusetts Route 128 Impact Study was to investigate land use changes that have taken place along Route 128, the basic factors underlying such changes, and the traffic generation characteristics of the industrial development adjoining the highway. In addition, an attempt was made to evaluate the impact of this development and its traffic on Route 128 and on the metropolitan area. The work was sponsored by the Massachusetts Department of Public Works with the cooperation of the United States Bureau of Public Roads.

This report deals with some of the principal findings of the industrial and residential development surveys, and discusses the methodology used. It supplements an earlier report on industrial development (1). The traffic phase of the study is presented in a separate paper (2).

The Route 128 study was authorized in the summer of 1956. Work started on pilot studies in the fall of 1956. The industrial and employee travel pattern surveys were conducted in the summer of 1957 and represent the status of industrial development as of September 1957. The residential survey and analysis of employee traffic patterns and origins and destinations of Route 128 traffic were made in the summer of 1958. During the writing of the report, certain statistics were brought up to September 1958.

The full industrial and residential development of properties along Route 128 has by no means been attained. In fact, in many areas it has just started or has yet to start. The study, therefore, cannot be more than a progress report of what the ultimate impact of the highway will be.

DESCRIPTION OF ROUTE 128

Route 128 is a limited-access, divided 4- and 6-lane circumferential highway extending for about 60 miles around metropolitan Boston. Since the ocean lies to the east of the city, the highway actually describes a semi-circle on the western side about 10 miles from the central business district. The highway has been constructed in stages since 1933. The most important central link was completed in 1951 providing for the first time a continuous, high-speed route around the city with frequent interchanges at important radial highways. The major development along the highway dates from this year. Further improvements have been made and are still in progress at the southerly end of the route.

Traffic volumes range from 40,000 to 50,000 vehicles per day, in the middle section of the road, and are less on the two ends. The construction and land costs for the 57 miles completed to September 1957 was about $62,500,000.

UNIQUE CHARACTER OF ROUTE 128

By locating Route 128 in vacant land just outside existing developed areas, it was possible to meet most engineering requirements, bypass the centers of towns surrounding Boston, keep land costs low and avoid disturbing home owners. As a circumferential highway, the route cut across large sectors of undeveloped land between older radial highways.

Both the timing and location of the highway were ideal for opening up land necessary to satisfy the outward (or suburban) movement of people and industry which took place in the post-war period. The highway gave access to low-priced land in areas on the edge of the metropolitan labor market, not too far from the core of the city and yet close to attractive suburbs. At the same time many in-town businesses were expanding to the point where they could no longer operate efficiently in obsolete buildings on cramped sites. Developers took advantage of this situation and promoted the development of Route 128 industrial sites. In considering the phenomenon of Route 128 these factors should be taken into account.

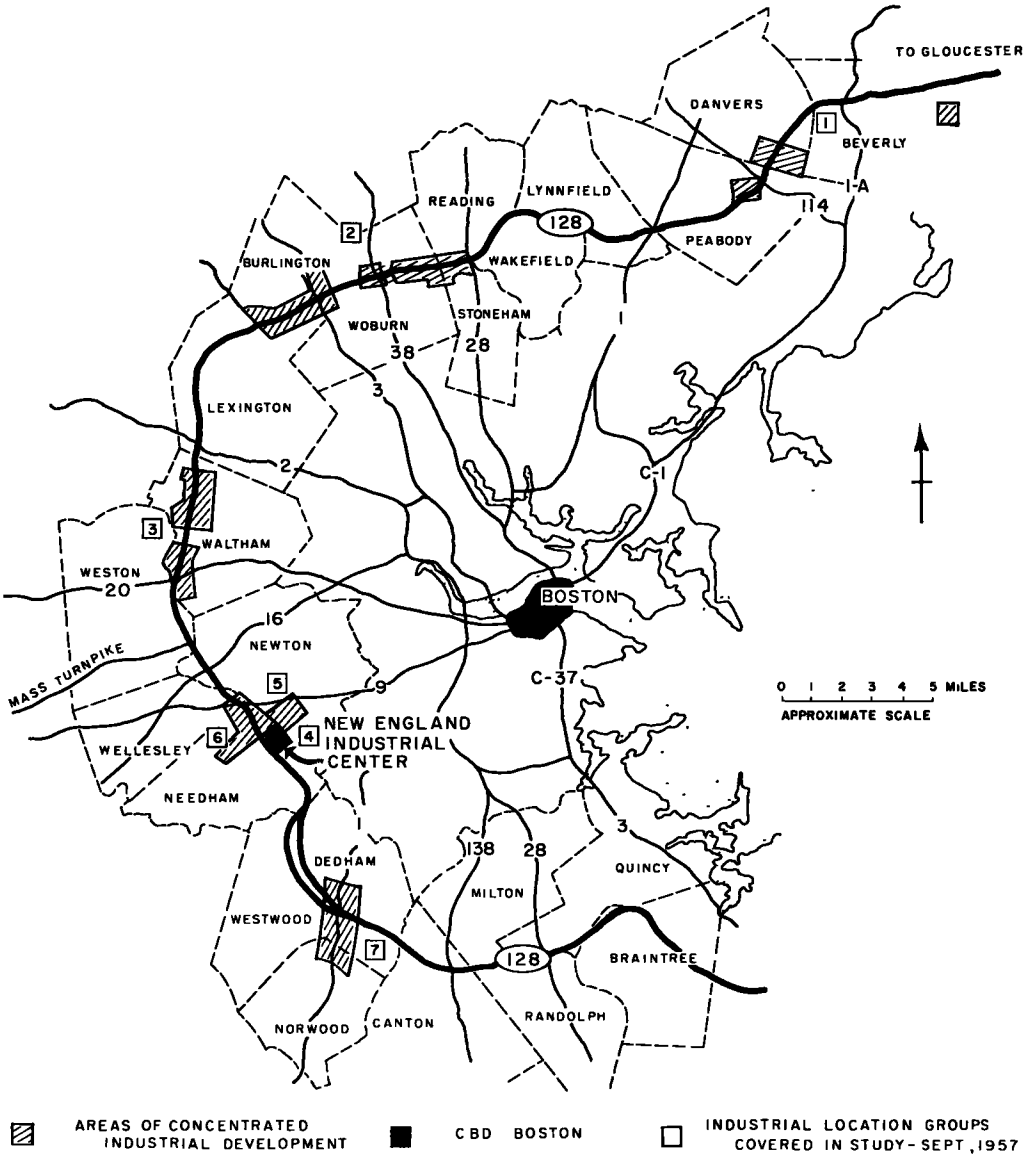


Figure 1. Layout of Route 128 showing areas of industrial development.

TABLE 1

STATISTICS OF NEW ROUTE 128 PLANTS

Locational Area	Type of Industry	Number of Plants	Percent of Total Plants	Total Employment	Average Employment at Present Site	Total Land Area	Average Land Area	Building Area	Land/Building Area Ratio	Total Investment (in dollars)				Average Investment (in dollars)			Percent of Total Investment	
						(in square feet)				Building	Land	Equipment	Total	Building	Land	Total	Building	Land
Area #1	Prod.	2	5.13	2450	1225.0	3,833,280	1,916,640	270,000	14.22	2,700,000	172,000	3,714,000	6,586,000	1,350,000	86,000	3,293,000	41.00	2.61
North of U.S. 1 North	R. & D.																	
	Dist.																	
	Service																	
	All Inds.	2	2.08	2450	1225.0	3,833,280	1,916,640	270,000	14.22	2,700,000	172,000	3,714,000	6,586,000	1,350,000	86,000	3,293,000	41.00	2.61
Area #2	Prod.	6	15.38	2365	394.0	14,819,400	2,469,900	355,650	41.67	6,399,000	591,050	4,507,000	11,497,050	1,066,500	98,508	1,916,175	55.66	5.41
Burlington and	R. & D.	3	33.33	455	151.7	827,640	275,880	108,000	7.66	1,535,000	151,000	846,000	2,532,000	511,667	50,333	844,000	60.62	5.96
North to U.S. 1 North	Dist.	5	11.90	172	34.4	1,428,580	285,716	79,600	17.95	815,000	97,000	373,000	1,285,000	163,000	19,400	257,000	63.42	7.55
	Service																	
	All Inds.	14	14.58	2992	213.7	17,075,620	1,219,687	543,250	31.62	8,746,000	839,050	5,726,000	15,314,050	624,929	59,932	1,093,861	57.13	5.48
Area #3	Prod.	7	17.95	3001	428.7	9,888,430	1,412,633	1,538,356	6.43	5,464,732	763,633	4,770,327	10,998,692	780,676	109,090	1,571,242	49.69	6.94
Waltham	R. & D.	2	22.22	1110	555.0	767,256	383,628	170,680	4.50	930,000	361,600	1,585,500	2,877,100	465,000	180,800	1,438,550	32.32	12.57
	Dist.	1	2.38	44	44.0	108,000	108,000	39,000	2.77	485,000	54,000	215,000	754,000	485,000	54,000	750,000	64.67	7.20
	Service	2	33.33	318	159.0	3,804,095	1,902,048	81,800	46.63	1,723,000	277,000	——	2,000,000	861,800	138,500	1,000,000	86.15	13.85
	All Inds.	12	12.50	4473	372.8	14,567,781	1,213,982	1,829,836	7.96	8,602,732	1,456,233	6,570,827	16,629,792	716,894	121,353	1,385,483	51.74	8.76
Area #4	Prod.	4	10.26	1244	311.0	2,102,386	525,965	678,000	3.10	6,325,784	1,303,769	1,568,725	9,198,278	1,581,446	325,942	2,299,570	68.77	14.17
N.E.I.C.	R. & D.	2	22.22	66	33.0	70,000	35,000	31,000	2.26	487,285	35,257	160,000	682,542	243,643	17,629	341,271	71.39	5.17
	Dist.	15	28.00	840	56.0	1,778,664	118,578	792,910	2.24	5,696,465	1,030,488	408,500	7,135,453	379,764	68,699	475,697	79.83	14.44
	Service	1	16.67	26	26.0	15,000	15,000	3,000	5.00	60,000	13,159	35,000	108,159	60,000	13,159	108,159	55.47	12.17
	All Inds.	22	22.92	2176	98.9	3,966,050	180,275	1,504,910	2.64	12,569,534	2,382,673	2,172,225	17,124,432	571,361	108,303	778,383	73.40	13.91
Area #5	Prod.	4	10.26	512	128.0	461,358	115,340	133,760	3.45	838,145	465,665	330,000	1,633,810	209,536	116,416	408,453	51.03	28.50
Newton	R. & D.	1	11.11	500	500.0	200,000	200,000	60,000	3.33	675,000	300,000	180,000	1,155,000	675,000	300,000	1,555,000	58.44	25.97
	Dist.	11	26.19	618	56 2	1,171,434	106,494	373,721	3.13	3,478,000	1,288,900	1,438,400	6,205,300	326,181	117,173	564,118	56.05	20.77
	Service	1	16.67	150	150.0	28,000	28,000	5,300	5.09	60,000	40,000	——	100,000	60,000	40,000	100,000	60.00	40.00
	All Inds.	17	17.71	1780	104.7	1,860,792	109,458	572,981	3.25	5,051,145	2,094,565	1,948,400	9,094,110	297,126	123,210	534,948	55.54	23.15
Area #6	Prod.	7	17.95	65	9.3	147,164	21,023	37,300	3.95	502.000	133,900	148,000	783,900	71,714	19,129	111,986	64.04	17.08
Needham	R. & D.																	
	Dist.	8	19.05	302	37.8	714,295	89,287	152,460	4.69	1,433,000	574,848	358,550	2,366,398	179,125	71,856	295,800	60.56	24.29
	Service																	
	All Inds.	15	15.63	367	24.5	861,459	57,431	189,760	4.54	1,935,000	708,748	506,550	3,150,298	129,000	47,250	210,020	61.42	22.50
Area #7	Prod.	9	23.08	2750	305.6	4,896,700	544,078	795,500	6.16	9,711,000	1,002,000	4,697,000	15,410,000	1,079,000	111,333	1,712,222	63.02	6.50
South of Needham	R. & D.	1	11.11	45	45.0	130,700	130,700	16,000	8.17	252,500	25,000	300,000	577,500	252,500	25,000	577,500	43.72	4.33
	Dist.	2	4.76	26	13.0	202,460	101,230	35,000	5.78	200,000	48,000	12,000	260,000	100,000	24,000	130,000	76.92	18.46
	Service	2	33.33	17	8.5	734,795	367,398	37,000	19.86	480,000	135,000	500,000	1,115,000	240,000	67,500	557,500	43.05	12.11
	All Inds.	14	14.58	2838	202.7	5,964,655	426,047	883,500	6.75	10,643,500	1,210,000	5,509,000	17,362,500	760,250	86,429	1,240,179	61.30	6.97
All Areas	Prod.	39	40.63	12387	317.6	36,148,718	926,890	3,808,566	9.47	31,940,661	4,432,017	19,735,052	56,107,730	818,991	113,641	1,438,660	56.93	7.90
	R. & D.	9	9.38	2176	241.8	1,995,596	221,733	385,680	5.17	3,879,785	872,857	3,071,500	7,824,142	431,087	96,984	869,349	49.59	11.16
	Dist.	42	43.75	2002	47.7	5,403,433	128,653	1,472,691	3.67	12,107,465	3,093,236	2,805,450	18,006,151	288,273	73,648	428,718	67.24	17.18
	Service	6	6.25	511	85.2	4,581,890	763,648	172,300	35.99	2,323,000	465,159	535,000	3,323,159	387,167	77,527	553,859	69.90	14.00
	All Inds.	96	100.00	17076	178.9	48,129,637	501,350	5,794,237	8.31	50,250,911	8,863,269	26,147,002	85,261,182	523,447	92,326	888,137	64.96	10.40

INDUSTRIAL SURVEY

This survey included new industries located roughly within a mile of Route 128 between Route 1A in Beverly (north of Boston) to Route 138 in Canton (south of Boston), a length of about 55 miles (Fig. 1). Most of the plants were near enough to the route to be clearly visible from it.

Advance letters were sent to the management of each plant to be surveyed and interviews arranged. A management questionnaire (1) was designed to obtain information regarding investment in plant, number of employees, former location, parking facilities, etc., the second part asked qualitative questions, such as factors considered in choosing location on Route 128, other sites considered, labor procurement problems, and benefits expected and received.

During the summer of 1957, contacts were made with 99 plants and complete data obtained from 96.

RESULTS AND ANALYSIS OF INDUSTRIAL SURVEY

Separation of Industries by Type and Location

For analysis purposes, industries were divided into four types: (a) distribution, (b) production, (c) research and development, and (d) service. Geographically, they were separated into seven locational areas, as shown in Figure 1.

The group of plants in the Needham-Newton area were separated into three units to preserve the identities of the New England Industrial Center (NEIC) and the Newton Industrial Center, leaving other Needham plants in a third group. By separating the industries into locational groups it is possible to isolate some of the regional factors influencing choice of site, employee travel patterns, shifts in employee residences, etc. Some of the basic statistics obtained from Route 128 industries are shown in Table 1.

TABLE 2

PERCENTAGE DISTRIBUTION OF INVESTMENT, EMPLOYMENT, AND NUMBER OF PLANTS BY TYPE OF INDUSTRY ON ROUTE 128

Type of Industry	Percent of Investment	Percent of Employment	Percent of Number of Plants
Distribution	21.1	11.7	43.7
Production	65.8	72.6	40.6
Research & Development	9.2	12.7	9.4
Service	3.9	3.0	6.3
All Types	100.0	100.0	100.0

In making comparisons by types of industry or by locational groups, use is made of percent of investment and percent of employment in the plants involved. In this way, the magnitude of operations involved is revealed more significantly than by considering number of plants alone. For example, in Table 2, distribution type industries comprise 43.7 percent of total number of plants but account for only 11.7 percent of employment and 21.1 percent of investment. It is evident that comparisons based on number of plants would give a distorted picture of the true relationships.

Investment, Employment and Other Characteristics of Route 128 Plants

The capital investment in the 96 plants in operation on Route 128 by September 1957 amounted to $85,000,000 and the employment to 17,000 persons. Plants completed or under construction since that date have an estimated investment of $52,000,000 and employment of 10,500. Approximately 60 percent of this additional development was completed by September 1958.

Table 1 shows the distribution of total investment, employment and number of plants in each of the seven locational areas, with a further separation by type of industry. The locational areas are identified in Figure 1.

Three of the industrial location groups are immediately adjacent to each other and are served by the same Route 128 interchange (Highland Ave.). They are Location Areas 4, 5 and 6 (NEIC, Newton and Needham). These three groups when combined represent about one-third of the Route 128 investment and about one-quarter of the employment. When the adjoinging Location Area 3 (Waltham) to the north is added, one-half of both investment and employment is included. It is significant that these areas of such large concentration of industry are centrally located on Route 128, close to major radial highway Routes 9 and 20, and to the Massachusetts Turnpike. These three highways carry the major flow of traffic from Boston to the west and south.

TABLE 3

INVESTMENT AND EMPLOYMENT AT NEW ROUTE 128 COMPANIES BY CLASSIFICATION AND TYPE OF INDUSTRY[1]

Classification	Investment				
	Type of Industry				Total
	Distribution	Production	R. & D.[2]	Service	
"New" Industries	$ 110,598	$ 846,000	$1,155,000	$ 0	$ 2,111,598
"New" Branch Plants	1,329,499	14,268,781	1,099,357	950,000	17,647,637
Relocated Industries	7,118,171	31,077,759	3,284,285	2,208,159	43,688,374
Relocated Branch Plants	9,447,883	9,915,190	2,285,500	165,000	21,813,573
Total Investment	$18,006,151	$56,107,730	$7,824,142	$3,323,159	$85,261,182
Percent of Total Investment	21.1	65.8	9.2	3.9	100.0

Classification	Employment				
	Type of Industry				Total
	Distribution	Production	R. & D.[2]	Service	
"New" Industries	20	54	500	0	574
"New" Branch Plants	84	2,897	130	9	3,120
Relocated Industries	893	6,600	646	494	8,633
Relocated Branch Plants	1,005	2,836	900	8	4,749
Total Employment	2,002	12,387	2,176	511	17,076
Percent of Employment	11.7	72.6	12.7	3.0	100.0

Classification	Percent Investment				
	Type of Industry				Total
	Distribution	Production	R. & D.[2]	Service	
"New" Industries	0.6	1.5	14.8	0	2.5
"New" Branch Plants	7.4	25.4	14.1	28.6	20.7
Relocated Industries	39.5	55.4	41.9	66.4	51.2
Relocated Branch Plants	52.5	17.7	29.2	5.0	25.6
Total	100.0	100.0	100.0	100.0	100.0

Classification	Percent Employment				
	Type of Industry				Total
	Distribution	Production	R. & D.[2]	Service	
"New" Industries	1.0	0.4	23.0	0	3.4
"New" Branch Plants	4.2	23.4	6.0	1.8	18.3
Relocated Industries	44.6	53.3	29.7	96.6	50.5
Relocated Branch Plants	50.2	22.9	41.3	1.6	27.8
Total	100.0	100.0	100.0	100.0	100.0

[1] Based on 96 new plants in operation along Route 128 in September 1957 of which 77 were relocated.
[2] Research and Development.

Classification of New Companies on Route 128

In this section another classification is used to distinguish between companies which opened for the first time and those which merely relocated from other sites. New industries or branch plants represent the inauguration of new business enterprises or outlets which were just started or founded. Relocated industries or branch plants indicate those firms which moved to Route 128 from other locations. A further separation is made between industries which only have one plant or have their headquarters plant on Route 128, and branch plants which are an outlet or subdivision of a company. The investment and employment in each class of plant is given by industry types in Table 3.

Determination of Net Gains to the Metropolitan Area Contributed by the Route 128 Industrial Development

The investment in new industries and new branch plants represents a gain for the Route 128 locality and also for the metropolitan area. Similarly the employment at these new companies represents new job opportunities in the Route 128 locality and in the metropolitan area. The investment and job opportunities at relocated companies and branches represent an addition to the Route 128 locality, but may or may not be a net gain for the metropolitan area, depending upon the investment and employment changes at the sites vacated by the companies that moved to Route 128. Consequently, in order to determine the gain to the metropolitan area represented by the industry on Route 128, it is necessary to consider the new and relocated companies separately and to determine any in-town losses occuring at the former sites of the relocated firms. Essentially, all of the new industry investment and employment is considered a gain, while the relocated industry gains must be offset by the in-town losses.

In order to determine the net gains or losses, an investigation was needed of conditions at the former sites of relocated firms. Since only a sample of such firms was investigated, it was necessary to determine the loss for the sample and then expand this figure to represent the total for all relocated companies.

Investigation of Conditions at Former Sites of Relocated Companies

The former locations of companies that moved to new locations on Route 128 are shown in Figure 2. Most of these companies' former plants (or branches) were located near the heart of downtown Boston. In terms of total investment in relocated companies, 68 percent were formerly situated within a 2¼-mile radius of the city center (State House) and 96 percent were within a 4½-mile radius.

In the spring of 1958 an investigation was made of the disposition of the in-town sites vacated by 25 of the 77 relocated companies now on Route 128 (this investigation was conducted as part of a thesis, "The Re-Use of Vacated Commercial Sites in Downtown Boston," by Brigitte G. Orent, submitted in partial fulfillment of the requirements for the degree of Master of City Planning, Department of City and Regional Planning, Massachusetts Institute of Technology, June 1958, pages 16-18). This sample represents 28 percent of employment and 38 percent of the investment in the relocated companies included in the September 1957 survey. Prior to moving, these companies occupied 32 in-town sites.

Of the floor space formerly occupied, 64 percent was in use (spring 1958), 32 percent was vacant and 4 percent had been demolished for highway construction. Some of the characteristics of the in-town sites before and after companies moved to Route 128 are given in Table 4.

The in-town sites were reoccupied by 61 companies having 45 percent less employees, and 33 percent less floor space, resulting in an increase of 23 percent in floor space per employee. This suggests that the companies moving into the vacant space left by Route 128 industries were seeking space to expand their activities. This was substantiated by questions directed to 44 of the 61 companies asking why they left their old sites. The replies are summarized as follows by percent of companies:

(1) 54 percent expanding and wanting more space and/or facilities.
(2) 25 percent displaced by public improvements (highway and garages).
(3) 14 percent displaced by private parties.
(4) 7 percent old space too expensive for their operations.

Information on site selection factors considered by companies now on Route 128 (presented in a later section) shows that a major factor influencing their choice of site was need of land for expansion and for increased operational efficiency. Hence it appears that some of the motives behind the companies which filled the vacancies left by Route 128 industries were much the same as those which brought the vacating industries to Route 128.

Estimate of Investment and Employment Opportunities Added in Metropolitan Boston Area by Route 128 Plants

As pointed out in "Determination of Net Gains to the Metropolitan Area Contributed by the Route 128 Industrial Development" the investment and jobs provided by new Route 128 companies doing business for the first time represents a gain not only to the Route 128 locality, but also to the Boston Metropolitan Area. From Table 3 an investment is found of about $20,000,000 in new plants and an employment of 3,700.

TABLE 4

UTILIZATION OF IN-TOWN SITES FORMERLY OCCUPIED BY COMPANIES NOW LOCATED ON ROUTE 128

In-Town Site Characteristics	BEFORE Companies Moved to Route 128	AFTER Route 128 Companies Vacated Sites
Number of Sites Occupied	32	25
Number of Firms Occupying Sites	25	61
Assessed Valuation	$16,299,000	$14,602,000
Total Employment	2701	2028
Total Sq Ft Floor Space Used	1,089,000	696,960[1]
Avg. Floor Space per Company	41,900	11,360
Avg. Floor Space per Employee	279	342
Avg. Employees per Company	150	33

[1] Only 1,045,550 sq ft available for use due to demolition.

The capital investment and employment at relocated plants from Table 3 amounts to about $65,500,000 and 13,382 persons. This investment and employment represents a gain to the Route 128 locality, but only the increase over subsequent investment and employment at vacated sites is a gain to the metropolitan area.

Assessed valuation and employment both have dropped at the former sites of relocated companies since these firms have moved to Route 128 (Table 4). Part of this decrease or loss was due to demolition of buildings for public purposes. The exact amount of this demolition loss in valuation and employment is not known. If one assumes it to be proportional to the 4 percent of floor space removed, then a demolition loss of $16,299,000 x 0.04 = $652,000 in valuation and 3,701 x 0.04 = 148 in employment is found. The net loss at the in-town sites due to the relocation of firms to Route 128 was therefore $16,299,000 - 652,000 - 14,602,000 = $1,045,000 in assessed valuation and 3,701 - 148 - 2,028 = 1,525 in employment.

Some of the characteristics of the 25 firms who relocated on Route 128 are compared with data from 70 of the relocated firms on the highway in Table 5.

The 25 company sample has characteristics similar to those of the 70 relocated firms (which include the 25) with respect to average company investment, employment and building area, indicating the possibility of a representative sample. However, it was also found that the percent of increase in employment for the 25 firms before and

after relocating was substantially lower than that for the 70 firm group of relocated companies. Therefore, any estimates of net gain of employment contributed to the area by relocated companies based on the 25 company sample will tend to be on the conservative side.

The value of the Route 128 industry was obtained in terms of capital investiment rather than assessed valuation as the assessment policies of the metropolitan area towns vary considerably. Also, the in-town policy varies, the valuations usually being a larger proportion of investment for industrial and commercial properties than for residences. For the purpose of this analysis it is assumed that the $1,000,000 assessed valuation loss at the in-town properties vacated by 25 relocated Route 128 firms represents 50 percent of the investment. On this basis the loss in investment would be

TABLE 5

EMPLOYMENT AND INVESTMENT CHARACTERISTICS OF 25 ROUTE 128 COMPANIES FORMERLY LOCATED IN-TOWN AND COMPARISON WITH 70 RELOCATED ROUTE 128 COMPANIES SURVEYED IN 1957

Number of Companies	25	70
Total Capital Investment	$24,955,000	$62,990,000
Total Employment	3,810	12,298
Total Building Area (sq ft)	1,614,550	3,850,961
Avg. Investment per Company	$998,193	$899,857
Avg. Employment per Company	159	176
Avg. Building Area per Company (sq ft)	64,582	55,014
Avg. Building Area per Employee (sq ft)	422	313

about $2,000,000 for the 25 relocated plants having a total investment of $24,955,000 (Table 5). The net gain to the area for this 25 plant sample then becomes about $23,000,000.

The total investment for all relocated companies on Route 128 (September 1957) was $65,500,000. When the net gain for the 25 firms is expanded in proportion to the investment ratio, the net gain for all relocated companies becomes:

$$\$23,000,000 \times \frac{65,500,000}{25,000,000} = \$60,000,000.$$

If this last amount is further projected to include plants completed or under construction since September 1957, it becomes:

$$\$60,000,000 \times \frac{137,000,000}{85,000,000} = \$97,000,000.$$

The investment in new industries and branches originating on Route 128 was about $20,000,000 in September 1957. When this figure is projected to include plants opened or under construction since that date, the gain from new industries is:

$$\$20,000,000 \times \frac{137,000,000}{85,000,000} = \$32,000,000$$

The net investment gains contributed to the metropolitan area by new and relocated companies are totaled and summarized in Table 7.

The employment expansion characteristics of 70 relocated companies which had complete data before and after moving to Route 128 are summarized in Table 6. All except service companies showed substantial expansion of their labor force, the largest increase taking place in production and research and development companies.

The net employment gain contributed to the area by the Route 128 companies will be analyzed in the same manner as that for investment. Earlier the net loss in employment at the in-town sites following the relocation of the 25 firm sample was shown to be 1,525. The Route 128 employment of these same firms was 3,810 (Table 5), making

TABLE 6

EMPLOYMENT AT RELOCATED COMPANIES (INDUSTRIES AND BRANCH PLANTS) BEFORE AND AFTER MOVING TO ROUTE 128[1]

Type of Industry	Employment			Percent Change Over Employment at Former Site
	Before	After	Change	
Distribution	1699	1866	+ 167	+ 9.8
Production	6664	8528	+1864	+28.0
R & D	1097	1546	+ 449	+40.9
Service	382	358	- 24	- 6.3
All Relocated Companies	9842	12298	+2456	+25.0

[1] Based on 70 of the 77 relocated companies in Table 3.

a net gain of 2,285 job opportunities for the sample. If this net gain is expanded in proportion to the employment represented by all relocated firms in operation by September 1957, the total becomes:

$$2,285 \times \frac{13,382}{3,810} = 8,000.$$

If this amount is projected to include plants completed or under construction since September 1957, the amount will be:

$$8,020 \times \frac{27,500}{17,000} = 13,000.$$

Again, the employment of the new industries and branches must be added to the above figures in order to obtain the total net gain of job opportunities in the area. As of September 1957, the employment in the new companies was 3,700, and when projected to include that of the new firms opened or under construction since that time, the total employment at new companies becomes:

$$3,700 \times \frac{27,500}{17,000} = 6,000.$$

The foregoing estimates of net gain in investment and employment opportunities in the area contributed by the Route 128 industrial development are summarized in Table 7. They are approximate, and can be considered reliable only to the extent that the methods used are valid and that the samples used are representative. Also, the estimates do not account for any additional losses in valuation or employment that may have occurred at places vacated by those companies that took the space formerly occupied by companies now on Route 128.

Net gain represented by the industrial development at Route 128 is, of course, not necessarily due to the construction of the highway. One way to determine the gain resulting from the building of Route 128 would be to determine how many of the plants would have been built without a new Route 128, and then to compare that investment (and employment) with what has actually been realized. Since it was not possible to determine the extent of industrial development had Route 128 not been built, this analysis presents only gains resulting from development along the highway.

Impact of Route 128 Industrial Development on the Metropolitan Area

A study by the Seminar Research Bureau of Boston College has stated that the economy of metropolitan Boston now provides about one million jobs, and that between 1955 and 1975 there will be an estimated 200,000 new jobs in the metropolitan area (3).

The total employment at Route 128 industries, including that expected at plants under

TABLE 7

SUMMARY OF ESTIMATES OF NET GAIN OF INVESTMENT AND EMPLOYMENT OPPORTUNITIES IN THE METROPOLITAN AREA CONTRIBUTED BY THE INDUSTRIAL DEVELOPMENT ON ROUTE 128

Net Gains to the Area Contributed by:	Investment	Employment
96 Plants Surveyed as of September 1957	$80,000,000	11,700
Plants Completed or Under Construction Between Sept. 1957 and Sept. 1958	$49,000,000	7,300
All Plants Completed or Under Construction as of September 1958	$129,000,000	19,000

construction by September 1958, was estimated in section "Investment, Employment and Other Characteristics of Route 128 Plants" as 27,500. This represents only 2.7 percent of the million employees in the metropolitan area. The net gain of new job opportunities at Route 128 since 1955, however, represents about 6 percent of the 200,000 predicted new jobs by 1975. As industrial growth continues along Route 128, the impact of that highway on the greater Boston employment pattern will become more substantial.

The annual or total investment in new industrial building in the metropolitan area for all years between 1951 and 1957 could not be found. A study by the Greater Boston Chamber of Commerce, however, derived $84,790,000 for business development completed or under construction in 1957, and an additional $61,692,000 authorized (4). The Route 128 industry included in these figures was 35 percent and 45 percent, respectively. If the two estimates are combined, the portion of the development on Route 128 is 38 percent.

Benefits of Industrial Development to Individual Towns.

The previous sections estimated the net gains in employment and investment contributed to the metropolitan area by Route 128 industry. That discussion applied to the development along the entire highway, and not to any specific area. This section is included to illustrate the impact of industrial growth on two of the towns adjacent to the route.

The New England Industrial Center (NEIC) in Needham contains approximately 100 acres of land, 93 percent of which was developed by September 1957. Development in the center started in 1953 following a zoning change to allow industry. The assessed valuation of this property previous to the industrial activity was only $113,500. In 1957 the tax valuation following development of the NEIC was $5,729,300 or a net tax base gain of $5,615,800. At the 1957 tax rate of $52 per $1,000 of valuation, this valuation gain produced an increase of tax revenue to Needham of $292,000, or 9.6 percent of Needham's total real estate revenue even though this industrial site includes only 1.2 percent of the town's land acreage.

Figure 3 shows the trend in assessed valuations in Needham since 1946. The sharp rise in industrial values since 1954 is due to the New England Industrial Center, and the smaller rise in "other" industrial property valuation is due in part to new industries built near Route 128 in the vicinity of that Center. The flattening of the trend in tax rate (1954-57) is the result of these valuation increases. It amounts to about $5.00 per thousand below the projected 1946-54 trend. The significance of this retardation of the upward tax rate trend is evident when one considers that the average assessment on the Needham home owner is about $9,000 and that a savings of $5.00 per thousand amounts to $45.00 per year.

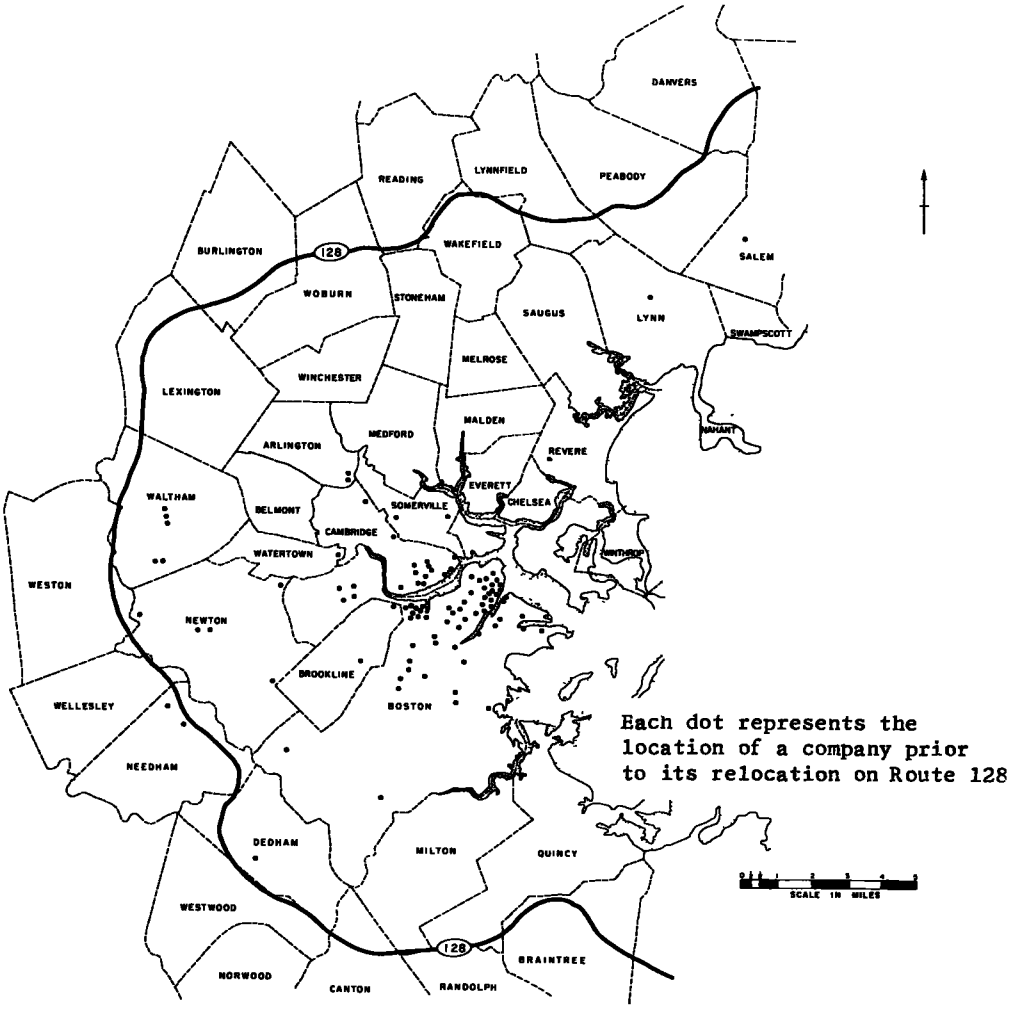
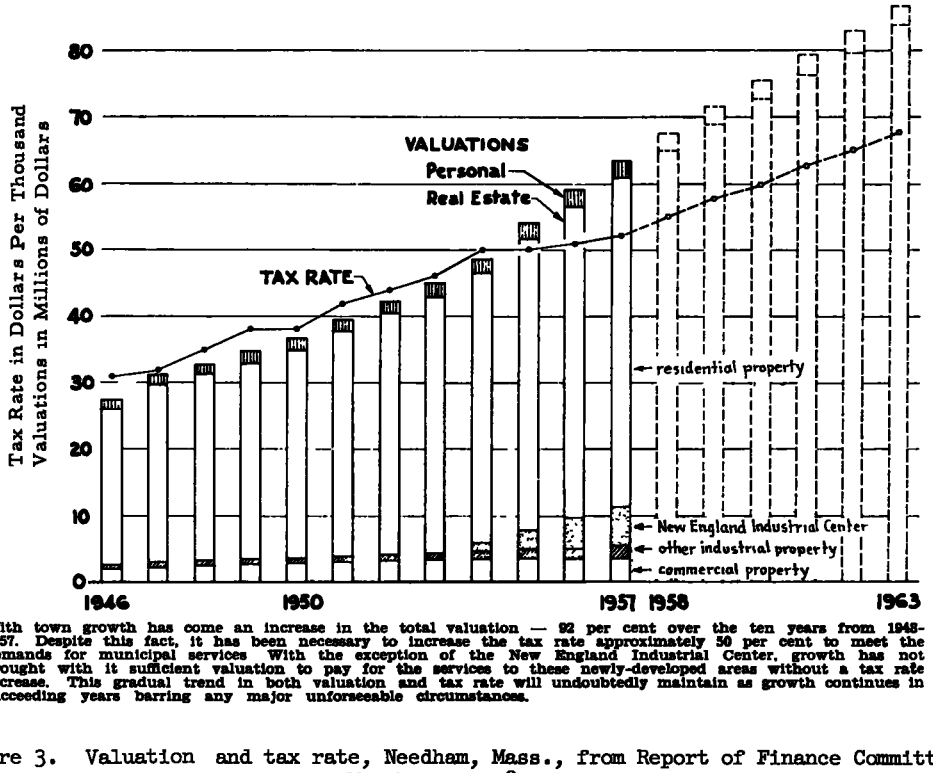


Figure 2. Former locations of companies which moved to Route 128 as of September 1957.

It might be argued that this industrial site if not rezoned would have been used for residential development. On the other hand, some town officials and land developers felt that the land would have been unsuitable for residential usage and would have remained vacant. However, assuming that the NEIC land was used for homes in place of industry, the probable gain or loss to the town of Needham has been estimated in the following manner.

The NEIC land area (with allowance for streets) could contain about 400 housing units, if the lot size were 10,000 sq ft. Using a tax valuation of 50 percent of an average sales price of $18,000 per house in 1957, the total residential tax base would be $3,600,000. The tax revenue from these imaginary residential properties at $52 per $1,000 would then be $187,000, or $105,000 less than the tax revenue from the actual industrial development even when the higher cost of town services to homeowners is neglected. The costs of town services to the NEIC is only about $25,000 per year, which without question is lower than it would be for 400 homes.

Waltham has experienced a similar advantage from its $22,000,000 of new plants along Route 128. Prior to the industrial growth, some of the developed area was



With town growth has come an increase in the total valuation — 92 per cent over the ten years from 1948-1957. Despite this fact, it has been necessary to increase the tax rate approximately 50 per cent to meet the demands for municipal services. With the exception of the New England Industrial Center, growth has not brought with it sufficient valuation to pay for the services to these newly-developed areas without a tax rate increase. This gradual trend in both valuation and tax rate will undoubtedly maintain as growth continues in succeeding years barring any major unforseeable circumstances.

Figure 3. Valuation and tax rate, Needham, Mass., from Report of Finance Committee, March 17, 1958.

unattractive and hardly feasible for residential properties. This peat-bog and pig-farm land has, however, been converted into a most attractive industrial center and research park. The new industrial properties contribute a net annual gain in gross tax revenue of approximately $400,000 (Jan. 1, 1958). However, for some years these gains will be offset by the interest and amortization costs on a $1,000,000 bond issue floated to extend the sewer system to the center.

The former value of land now occupied by industrial plants along Route 128 was low, in a range of $1,000 to $1,500 per acre. After being developed and built upon, the land values reported by occupants averaged $8,000 per acre. The total investment in land, plant and equipment averaged $77,000 per acre.

Relationship of Highway Construction and Zoning Changes to Rate of Industrial Development

Most of the discussion in the earlier portions of this report has dealt with the extent of the industrial activity along Route 128, its characteristics and its contribution of employment and investment to the towns adjoining the highway and to the metropolitan area. However, in order to determine the extent of the highway's influence on this activity it is pertinent to consider the yearly industrial growth along Route 128, the various stages of highway construction and the zoning changes that were made to allow industrial development.

The cumulative investment in new Route 128 industries for each year sinch 1951 is shown in Figure 4; the most important highway construction stages are also indicated on this figure.

The first spurt of development was primarily concentrated along the older, northern section of Route 128 in Locational Areas 1 and 2. Following this initial construction,

activity lagged for approximately two years while the communities along the road considered and adopted the necessary zoning changes to permit industry. Needham rezoned in 1953 to allow for the NEIC and Waltham followed in 1954 by rezoning about 300 acres for the Waltham Industrial Center and Research Park.

In the latter part of 1953 construction started in the NEIC just before and in anticipation of the re-building of old Route 128 south from Route 9. The bulk of the building activity in the center took place in 1954 and 1955 as the rebuilding of Route 128 neared completion. It is important to note that most of the industrial activity in the nearby Newton Industrial Center did not take place until reconstruction of old Route 128 was well under way. Similarly, most of the development in Dedham (Locational Area 7) coincided with or followed the rebuilding of Route 128 through that town.

Development in Waltham has been rapid since 1954, and has been even more active since 1957. The lag in its initial development was the result of lack of necessary zoning changes, and may have been retarded by the lack of a direct interchange with Route 128. This was added at Winter Street late in 1954. The major activity in Waltham followed that in the NEIC. Since September 1957 an additional $5,480,000 of industry has been completed or under construction in Waltham while only $1,000,000 has been added in the NEIC, which was 93 percent filled in 1957.

Other towns along Route 128 have followed Needham and Waltham in adopting the necessary zoning changes to permit industrial land uses. Wakefield, for example, in the fall of 1956 rezoned two areas, one for an industrial park yet to be developed and the other for the site of a recently completed multi-million dollar insurance building. In September 1958 Lexington took similar action to permit construction of a proposed $12,000,000 office building and research center on Route 128 near the Route 2 interchange.

Extent of Zoning for Industry and Relation to Plant Investment

An examination of zoning maps and regulations of the towns along the 55-mile length covered by the industrial survey shows that about 20 miles, or 21 percent of the frontage on the highway, which includes both sides of the road, is zoned for industrial or business uses. About 5,240 acres have been so zoned within one mile of the highway (September 1958). Table 1 indicates about 1,110 acres occupied by the 96 plants surveyed in September 1957. Plants completed or under construction since that date will bring the total occupied area to roughly 1,800 acres, or 34 percent of the zoned acreage within one mile of the highway. Hence it appears that there is as yet no shortage of available sites along Route 128, although the centrally located sites are being rapidly developed.

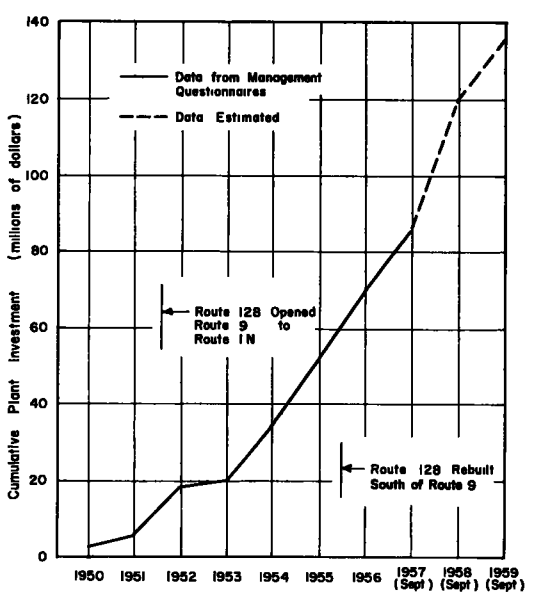


Figure 4. Cumulative total investment in New Route 128 plants by year of completion.

The greatest concentration of completed industrial development is in the NEIC with an investment of $185,000 per acre, amounting to $17,000,000 in 0.63 mile of frontage on Route 128. The concentration of investment is higher in the NEIC than can be expected in other areas (except the Newton Industrial Center) because the standards for land to building ratio were substantially lower than in subsequent developments. The total investment per frontage mile zoned for business or industry along Route 128, including establishments built and under construction as of September 1958, is estimated roughly as $7,000,000 per mile.

Explanation of Major Factors Influencing Route 128 Site Selection

In choosing a site on Route 128 each company was influenced by one or more factors, such as cost of site development, accessibility, space for expansion, labor market, taxes, and environment. One company might consider a given factor more important than another company. In the industrial survey it was hoped to bring out the major factors considered in order to provide data concerning the extent of the highway influence on the industrial growth.

When the management questionnaire was being prepared, consideration was given to attaching "weights" to the different replies, such as by asking the management to attach a percent of importance to each of the site selection factors which led them to locate on Route 128, or to list factors in the order of their importance. These methods were discarded as not likely to develop a reliable degree of distinction between one factor and another. Instead, it was decided to ask for only major factors, which, if more than one were given, could be considered of equal importance. To help reduce bias a list of factors was not suggested. Instead the officials being interviewed were asked to volunteer the major factors.

Each company stated their major site selection factors in different words, so a number of major factors were obtained. After a preliminary analysis of the interview replies, it was found that they could be grouped under fifteen headings as follows:

1. Land for Expansion.—Includes availability of enough land for both present and future space requirements. This space may be needed for enlarged production, more efficient operation in one-story buildings versus multiple story buildings, or a combination of these factors.

2. Labor Market.—Refers to labor market supply on Route 128 and ability of industry to acquire and hold labor force.

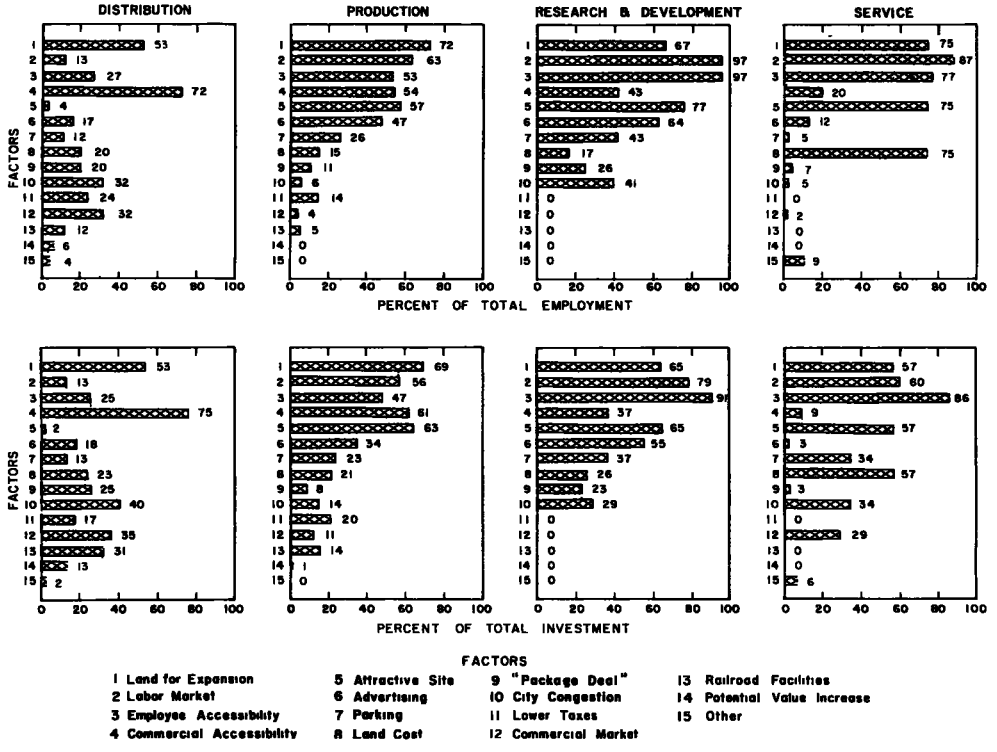


Figure 5. Rating of major factors considered in site selection by industries interviewed on Route 128—September 1957.

3. Employee Accessibility.—Refers to ease of access by employees involving savings in time and distance from home to work.

4. Commercial Accessibility.—Refers to ease of access for business purposes, such as truck pick-up and delivery, salesmen and business calls, and customers visits.

5. Attractive Site.—Indicates a desire to locate in a goodlooking site with respect to buildings and landscaping.

6. Advertising.—Includes expected benefit or increase in prestige to be derived from frequent viewing of signs and attractive grounds by passing motorists and potential customers.

7. Parking.—Implies need or desire to provide ample parking space for employees or trucking activity.

8. Land.—Indicated land cost was low, or lower than at other sites considered.

9. Package Deal.—Refers to the availability of a promoter who will provide a plant as a package, including land, preparation of site, erection of buildings to owner's specifications and aid in the financing of the project. Such plants may be acquired in different ways: some are bought outright, others are taken on lease, and others on lease with option to buy. The purchaser is relieved of the burden of site preparation and of dealing with many contractors. The developer is in a position to acquire desirable tracts of land at low price on a "wholesale" basis, and to gain economies from "volume" production of sites and buildings.

10. City Congestion.—Implies need or desire to move away from areas of severe traffic congestion.

11. Lower Taxes.—Refers to taxes being lower than at former site or at other sites considered, and also the prospect that taxes would not rise excessively in the future.

12. Commercial Market.—Indicates that the site selected offered more advantages in obtaining or holding their particular commercial market than their former or other sites.

13. Railroad Facilities.—Includes the necessity or desirability of having a rail siding available.

14. Potential Value Increase.—Implies that management officials expected their selected site to increase in value with time.

15. Other.—This includes any major factors listed by companies which did not fall into any other headings.

Evaluation of Major Site Selection Factors

For each of the fifteen factors a listing was made of the individual companies which indicated that factor as a major consideration. A company could be listed under one or more headings depending on the number of major factors given. For rating purposes, the investment and employment represented by each company were separately listed under each site selection factor and the amount in each category reduced to a percentage of total investment or employment. The results are shown in Figure 5.

The relative importance of the factors varies according to the particular needs of the industry types. The distribution plants stressed commercial accessibility and land for expansion; production companies emphasized land for expansion, attractive site, commercial accessibility, labor market, and employee accessibility. Those factors most important to research and development plants were employee accessibility, labor market, land for expansion, attractive site, and advertising. The most important factors to service industries were employee accessibility, labor market, land for expansion, attractive site and land cost.

The desire for better access shows up prominently for all companies; commercial access for distribution and production plants, and employee access for research and development and service companies. In this connection access is used in the broad sense to imply ease of access to all parts of the metropolitan or regional area. It does not apply to direct access to the highway which on Route 128 is limited to interchanges. The rapid growth of industry on Route 128 is witness to the fact that the advantages of regional access greatly outweigh the inconvenience caused by limiting access to the highway.

TABLE 8

PLANT SITES CONSIDERED PRIOR TO LOCATING ON ROUTE 128[1]

Type of Industry and Locational Area	Percent of Investment in Plants for Which		Percent of Investment Represented by Plants for which Other Sites were considered in				
	Only Rte. 128 Site Considered	Other Sites Considered	Downtown Boston	Boston Suburb	Other Rte. 128 Sites	Other Mass. Cities	Outside Mass.
A. TYPE OF INDUSTRY							
Distribution	20.4	79.6	25.9	79.5	38.8	38.3	0.0
Production	10.5	89.5	8.1	70.5	41.5	27.1	7.1
R & D	0.0	100.0	32.9	35.2	50.2	47.4	44.2
Service	4.2	95.8	4.7	16.4	88.3	0.0	0.0
B. LOCATIONAL AREA							
N. of Rte. 1	0.0	100.0	0.0	17.9	0.0	82.1	0.0
Burlington	3.2	96.8	9.4	66.2	36.0	15.4	0.0
Waltham	0.0	100.0	8.7	68.0	79.5	14.8	18.7
MEIC	49.6	50.4	58.9	78.5	9.7	3.3	0.0
Newton	5.6	94.4	18.9	81.1	42.3	0.0	6.4
Needham	61.7	38.3	5.4	94.6	69.0	0.0	0.0
South of Needham	0.5	99.5	11.4	71.6	46.5	0.0	20.6
ALL AREAS	11.5	88.5	14.4	66.6	43.5	14.9	9.6

[1] Based on 87 companies representing 92 percent of industrial plant investment on Route 128 in September 1957.

It can be concluded then that the need for accessibility, land for expansion, labor supply, along with an attractive site, were the most important factors behind the move of companies to Route 128. It can be argued that land for expansion, ample labor markets and attractive sites could be found in many parts of the metropolitan area. If this is true, the hypothesis is advanced that regional access, free of the traffic congestion so characteristic of in-town streets, was the factor that most influenced the industries in their decision to locate on Route 128 in preference to other sites.

Other Locations Considered by Companies Before Building on Route 128

In addition to establishing the effectiveness of Route 128 in attracting industries in preference to other locations, the management officials of industries were questioned regarding the consideration given to other sites before choosing their Route 128 location. The various sites considered, both inside and outside of Boston, were segregated into categories as shown in Table 8. The investment percentages represented by the plants in each category were entered under their appropriate headings. Since many companies considered more than one area, the investment percentage was included in more than one category. Consequently, the sum of the percentages in all categories is much more than 100.

The information in Table 8 clearly indicates that the great majority of all types of companies considered sites other than Route 128, although half of the industries in location 4 and 6 considered only their Route 128 site. Of those industries which considered other sites, most expressed an interest in suburban Boston or an alternate Route 128 location. The service industries gave much more consideration to alternate Route 128 sites than did the other industry types. This indicates a stronger attraction to Route 128 by these industry types. The research and development type showed a greater interest in other than Route 128 sites including downtown Boston, other Massachusetts cities and cities outside of the state.

The production type industries comprising 66 percent of Route 128 investment and 70 percent of employment, gave little consideration to downtown Boston sites, but were interested in suburban and alternate Route 128 sites. Apparently this type of

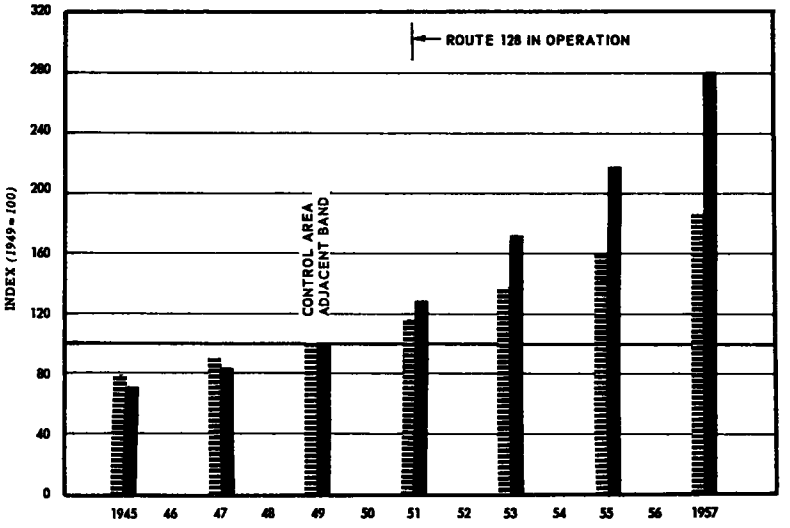


Figure 6. Index of assessments on taxable real estate in Lexington, Mass.—Adjacent Band Area and Control Area (rest of town).

industry is finding out-of-town sites most advantageous for its operations. Other industry types, although they actually chose a Route 128 location, gave more consideration to in-town sites, thereby suggesting a lesser desire to decentralize.

Considering all companies on Route 128, however, the urge to decentralize is evidenced by the fact that companies representing 55 percent of investment on Route 128 considered only a Route 128 location or another suburban site.

Benefits or Disadvantages, Expected or Realized by New Companies Locating on Route 128

The management officials of each firm were asked what benefits (or disadvantages) they expected because of the plant's proximity to Route 128, and what labor procurement and commuting problems they anticipated. Further, they were asked if these benefits were realized, and if they received other unanticipated advantages because of their particular relationship to the highway.

In nearly every case, management personnel stated that the expected benefits were closely related to the major factors in their decision to locate at their Route 128 site. In other words, if they chose their particular site because of the necessity for business accessibility, for example, they also expected that the route would provide this advantage or benefit.

In general, management felt the highway would provide access for business purposes and employees, and found this to be true. Most of the industries did not anticipate labor procurement or retention problems as they usually chose their particular site with regard to known labor markets and necessary access requirements. Generally they expected a higher quality of labor at the new site. However, those companies who located without regard to where their employees lived, or who employed principally unskilled and part-time help sometimes found difficulty in obtaining it at the new Route 128 location. For example, some of the industries are having this problem at the NEIC, which is not surprising when one considers that 47 percent of the old employees at that center had to change from public transportation and walking to automobiles.

For the most part, industries found their labor procurement problems much less difficult than anticipated. Quite often passing motorists voluntarily enter a Route 128 industry office seeking employment. On the other hand, those industries hiring engineers are finding some difficulty in holding them as these people can easily visit similar industries along the road during lunch hour and shop around for better job opportunities.

Some plants hiring principally secretarial personnel were hesitant in locating on the circumferential highway, as they felt it might be hard to retain this help due to the lack of car ownership and nearby shopping conveniences. However, most of these companies reported less turnover of secretarial help at the Route 128 location than in town.

A recent study sponsored by the Federal Reserve Bank of Boston concerned with some of the labor supply characteristics of Route 128 firms offers some information on the loss of personnel at the time a company transferred to Route 128, and on the annual quit or turnover rate at the new sites.

Of 21 firms having available data, the average percent of loss per company upon relocation was 7.7 percent. Those firms moving the farthest from their original site suffered the greatest loss. Also, it was brought out that those firms having the highest women-worker ratio had the highest relocation loss. Only 14 of the plants interviewed had information on the annual employment turnover rate following the relocation of the company at Route 128. Five of these were not able to make a comparison with the rate at their former site, but reported exceptionally low quit rates. Five of the remaining nine firms having before and after data had a definite decline in turnover, one had no change, and three had a higher quit rate than at their former site (5).

Some complaints have been made because of the lack of public transportation to and from the different plant locations along Route 128. However, in those cases where this service was offered after the company's move to Route 128, it was used by few employees, even in areas where more than 2,000 persons were employed, and therefore was discontinued. Some companies set up their own bus service to nearby towns, but almost all have since found this service unnecessary.

Many of the new establishments wanted to be located in a good-looking industrial park; some expressed the opinion that their personnel considered this quite important. Most companies are satisfied if not exceedingly proud, of being part of a good-looking industrial community.

Although few of the industries actually anticipated advertising or prestige value from from the highway, a number pointed out that they had received considerable benefit from this medium.

A disadvantage of Route 128 is the cost of access roads that would not be incurred at a downtown site. Following the construction of Route 128, there were few frontage type roads. In the development parks such as the NEIC, Waltham and Newton, the land developer provided the necessary access between the plant and Route 128 as required by the town zoning codes. Consequently, the cost of this service would necessarily be reflected in the cost of land as sold by the developers. In other cases individual companies found it necessary to build their own roads between their plant and Route 128 interchanges. In addition, the companies have had to make arrangements or buy the equipment for snow removal in their parking areas and on their private roads. At an in-town location, the municipality would have provided and maintained most of these facilities.

Another objection was made to the limited number of eating places along the road or in the vicinity of the industrial parks, and to the lack nearby shopping areas. Since the management interviews were conducted in September 1957, new eating establishments have been opened in Peabody, Lexington, and Dedham, and another is nearing completion in Waltham. These restaurants together with the present restaurant concessions should reduce this objection. The Northshore Shopping Center in Peabody was opened during 1958 and is within 15 minutes driving time of over 30 percent of the Route 128 employment. Also, another shopping center is being planned in Braintree, which when completed will be located within 15 minutes driving time of over 40 percent of the employment along Route 128.

RESIDENTIAL DEVELOPMENT STUDY

General

This study was undertaken to investigate the extent of residential activity along Route 128 and to isolate the effect of that route on this development. Studies of real estate activity were made in areas near the highway and in those farther away, and for years before and after the road was opened as a limited-access highway.

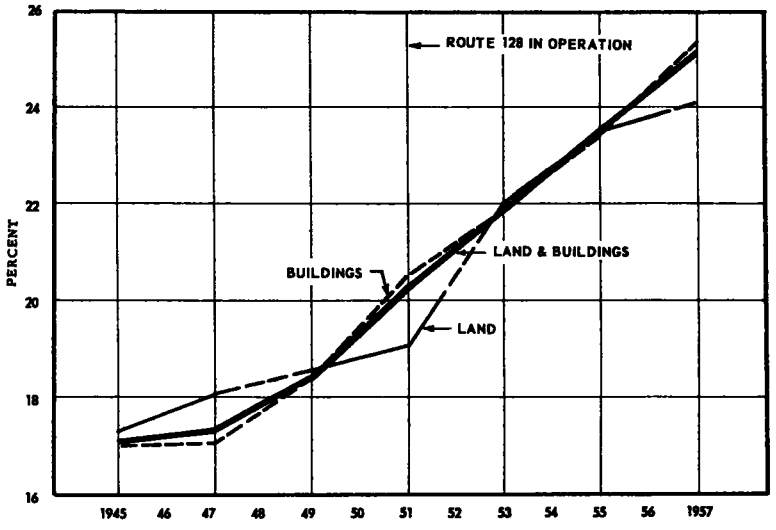


Figure 7. Assessed values in the adjacent Band Area of Lexington expressed as a percentage of assessed values in the entire town.

A pilot study in Needham indicated that considerable time and effort would be required to obtain real estate data for a single town. To obtain complete data for each of the 30 towns along Route 128 was beyond the scope of this study. Therefore, it was decided to concentrate on the towns of Needham and Lexington, each of which has about the same population, land area, distance from Boston, and length of Route 128. In Needham, the town center lies outside the arc of Route 128; in Lexington, it lies inside. Old Route 128 was first constructed in Needham in 1933 and later rebuilt as a limited-access highway in 1955. In Lexington the route was first opened as a new limited-access highway in 1951, replacing the old route which passed through the town center.

Procedure

Two general methods of approach were used in the study of highway influence. In the first an "adjacent band" area approximately one mile wide and roughly centered on the highway was chosen and compared with a "control area." In Lexington the adjacent band area (3,922 acres) was compared with the rest of the town (6,625 acres) as a control. In Needham the adjacent band area (1,187 acres) was compared with a control area (952 acres) located in another part of the town removed from Route 128.

In the second method, "access distance zones" were set off at 0-½, ½-1, and 1-½ miles travel distance from an interchange. These were compared with each other and also compared as a group with a "control zone" which in Lexington included areas within the town and over 1½ miles road distance from an interchange. In Needham, the control zone was a detached area in the same location as the control area. In every case the "zones" included only the land within 250 ft of each side of an existing street (as of September 1957); that is, the land built upon or available for building at that time. The access distance zones obviously increase in area with increasing distance from an interchange. In Lexington, for example, the nearest zone contained 262 acres, the next 801 acres, the next 1,353 acres, and the control zone contained 3,243 acres.

The indicators of residential real estate development which were examined included assessed valuations, building (or occupancy) permits, house densities and real estate sales. The period covered by the study was 1945 to 1957. In order to compare data for areas of different size, dwelling units were reduced to houses per acre, and sales data were expressed as indices based upon average of years 1948-50 = 100. These three years were taken as representative of the period just before the major link of Route 128 was opened to traffic.

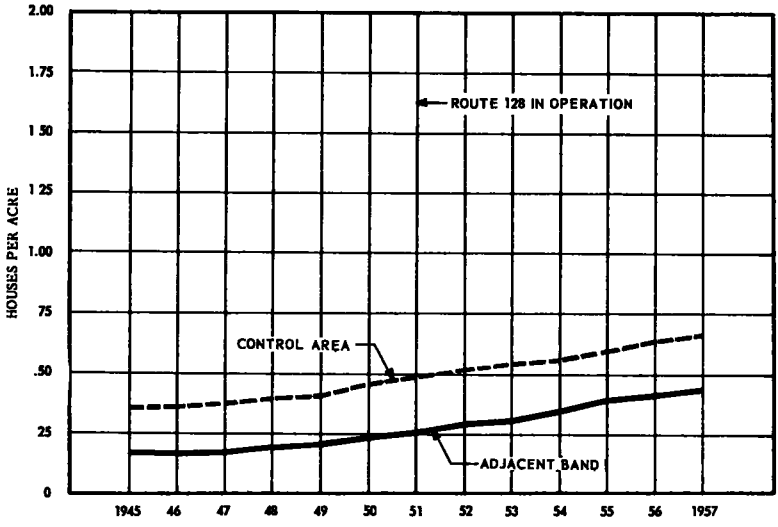


Figure 8. Density of houses—Lexington.

Data were gathered for the different types of study areas and control areas in the two towns, and are presented in considerable detail in the full report (6). In this paper only a few of the findings are illustrated and discussed.

Trends in Assessed Valuation of Real Estate in Lexington

Complete assessed valuation data for residential property were obtained in Lexington for every odd-numbered year from 1945 to 1957. The trend is illustrated in Figure 6 by an index graph based on average of 1948 - 1950 = 100 (in this case 1949 = 100). The average of these three years was adopted as representative of conditions before Route 128 was built and before it could have had an influence on adjacent land use. It will be noted from Figure 6 that since these base years, assessments in the adjacent band area

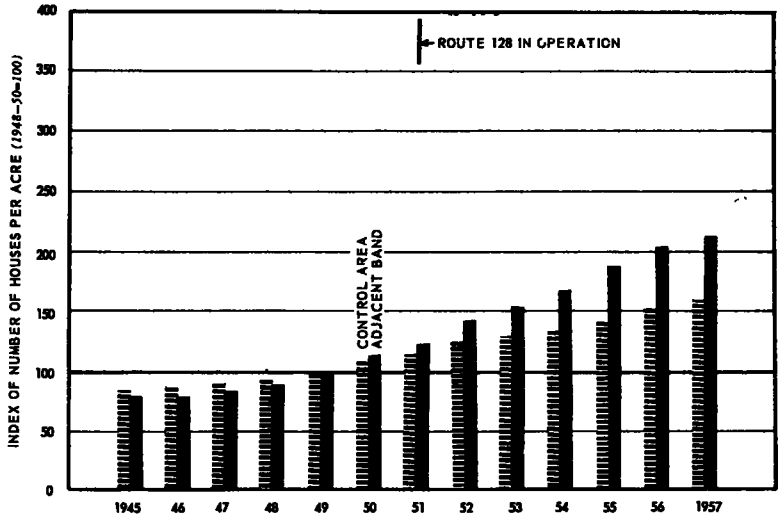


Figure 9. Index: Density of houses—Lexington.

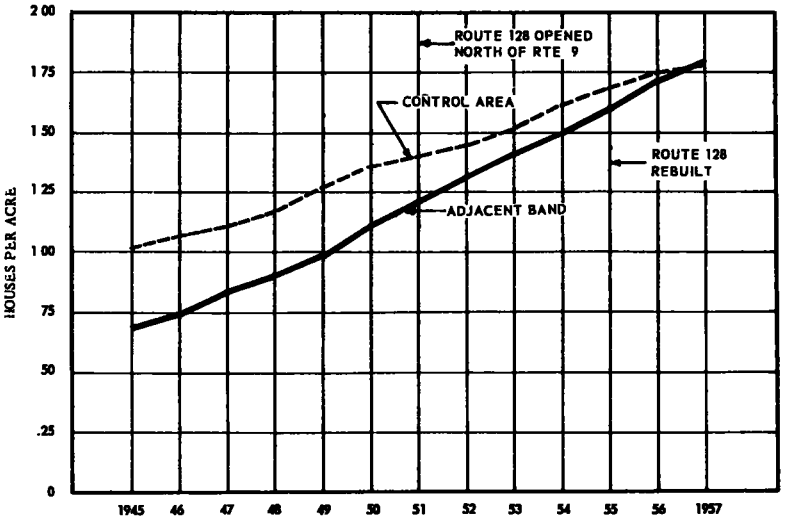


Figure 10. Density of houses—Needham.

have increased 180 percent while those in the rest of town increased 85 percent, indicating a more rapid rate of assessment growth with a corresponding increase in tax yield from the band area.

Figure 7 shows the increasing proportion of assessed value in the adjacent band with respect to the rest of Lexington. Using the assessed values for both land and buildings, it will be seen that in 1945, 17 percent of the entire town's assessed value was in the adjacent band. The percentage increased to 18 percent in 1949 and then climbed more rapidly to 25 percent in 1957. Since Route 128 was built, the growth in both areas has been accelerated, but the greater acceleration is taking place in the adjacent band.

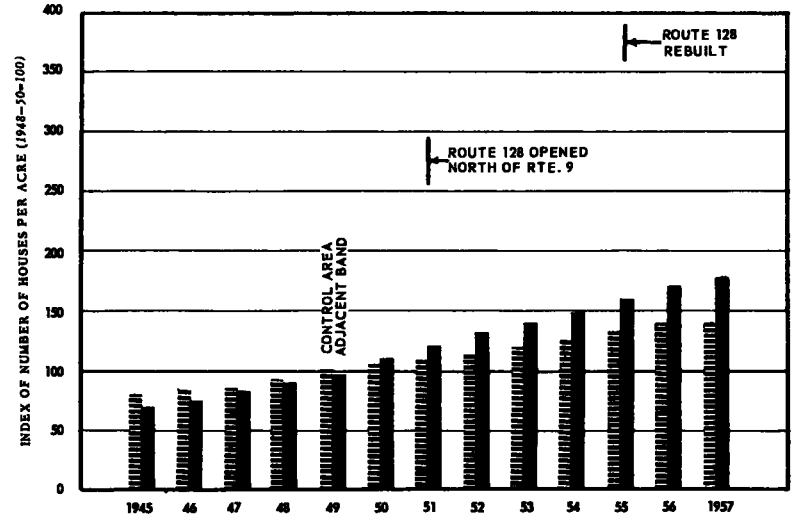


Figure 11. Index: Density of houses—Needham.

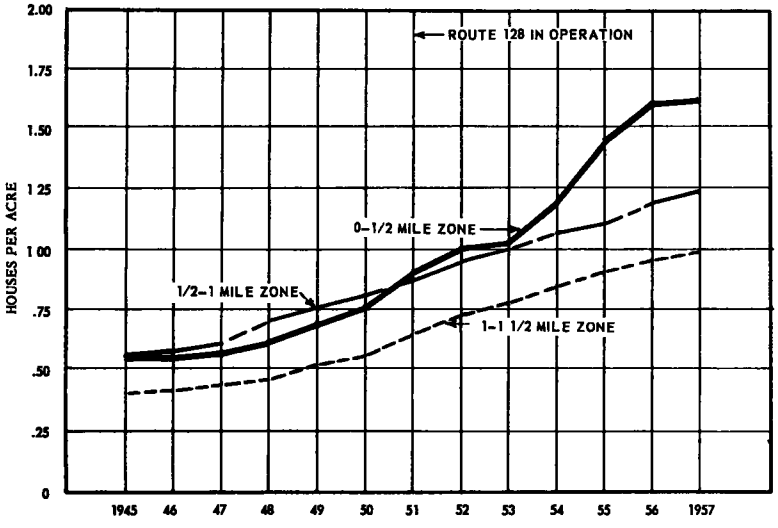


Figure 12. Density of houses in access distance zones—Lexington.

Trends in Houses per Unit Area

In order to obtain a measure of residential growth that would be representative of study areas of different gross areas, the number of houses standing in each area were reduced to a unit of houses per acre. These unit densities and their indices are shown for each year since 1945, in Figures 8 and 9 for Lexington and in Figures 10 and 11 for Needham. The increase in density is, of course, the result of new house construction. In Lexington the line plot (Fig. 8) shows higher densities in the control area, which is to be expected since the most populated parts of the town are in that area. In 1945 the band where Route 128 was later to be built was relatively undeveloped for residential purposes, and the house density was low. The two curves in Figure 8 are nearly parellel indicating about the same number of houses added in each area in each year.

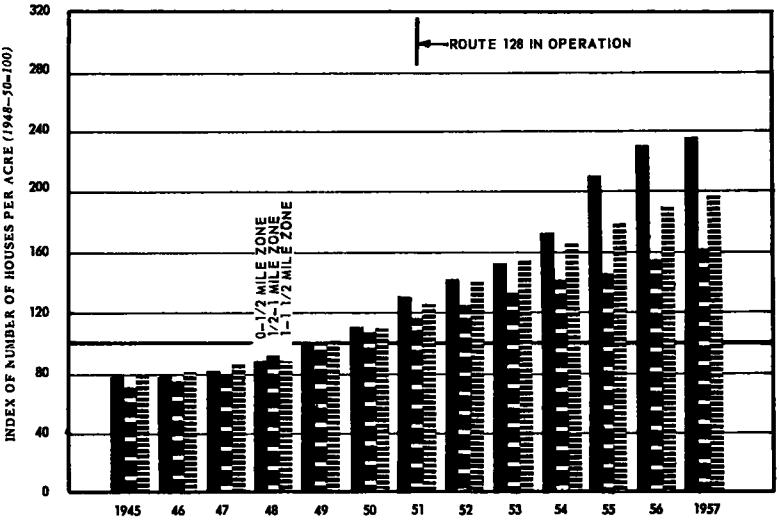


Figure 13. Index: Density of houses in access distance zones—Lexington.

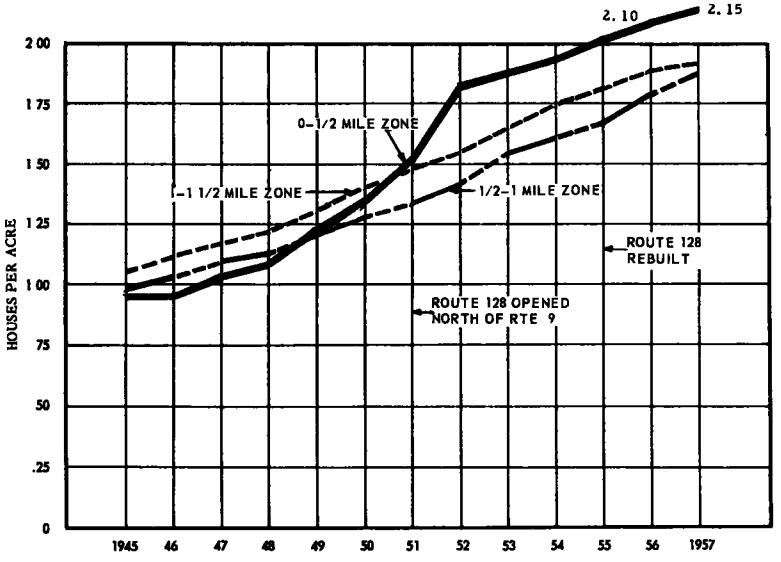


Figure 14. Density of houses in access distance zones—Needham.

In other words, the rate of increase is the same in both areas. The index graph (Fig. 9), however, shows that while the house density in the control area in 1957 was 58 percent over the 1948-50 average, that in the adjacent band was 112 percent greater. There was ample land available for home building in both the control area and in the adjacent band, even though the control area included the old part of Lexington.

Figure 10 shows the density of houses per acre in adjacent band and control areas in Needham. A more rapid growth in density is evident in the adjacent band than in the control area, especially since 1952. Based on average of years 1948-50 (Fig. 11) density increased 75 percent in adjacent band compared to 40 percent in control area. Residential growth near Route 128 has been active for many years, but has accelerated since Route 128 was rebuilt. In 1957 the two areas had about the same density. Since house lots are becoming scarce in both areas, the increase in building in each may be expected to diminish in future years.

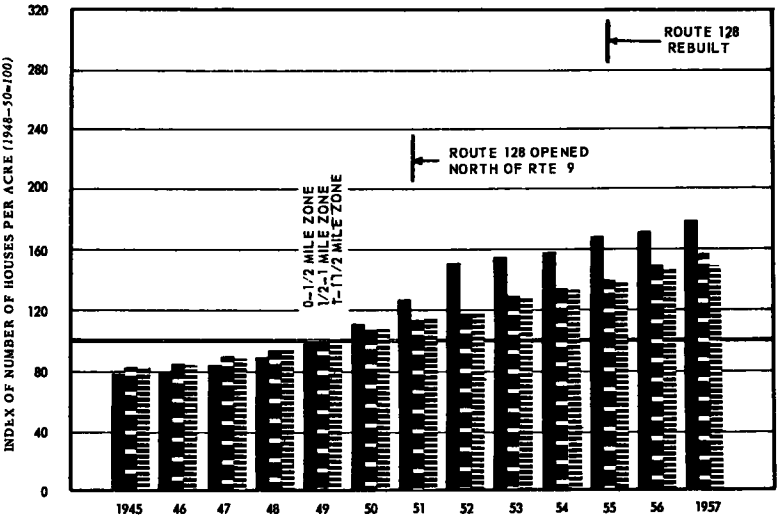


Figure 15. Index: Density of houses in access distance zones—Needham.

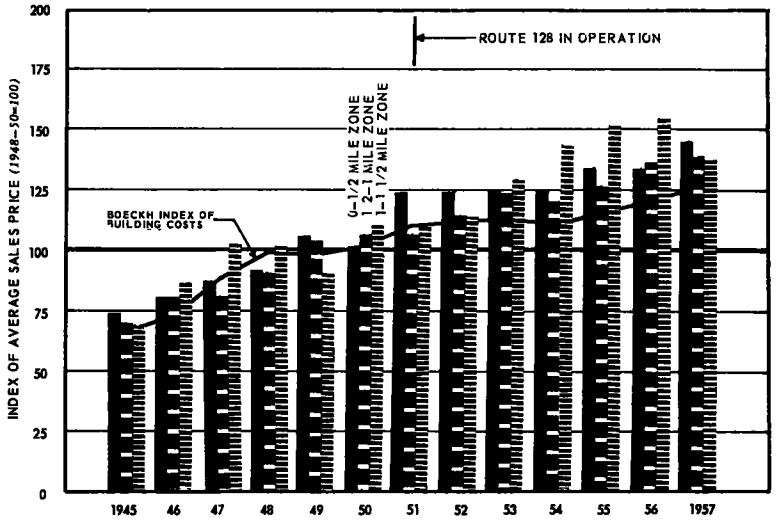


Figure 16. Average sales prices of houses built before 1942 in Lexington, Mass.—Index: Access distance zones.

The relative growth in house densities in the three access-distance zones is shown for Lexington in Figure 12, with corresponding indices in Figure 13. The trends are about the same in all three zones for years 1945 to 1953, after which the increase was greater in the 0-½ mile zone (from nearest interchange).

The increase in both 0-½ mile zone and in the adjacent band in Lexington have occured in spite of certain retarding influences in these areas, such as presence of low land less attractive for building sites than in other parts of town, presence of a transmission line, and the fact that sizable areas were either zoned for light industry or were being held off the real estate market pending zoning changes that would make them available for commercial or industrial purposes.

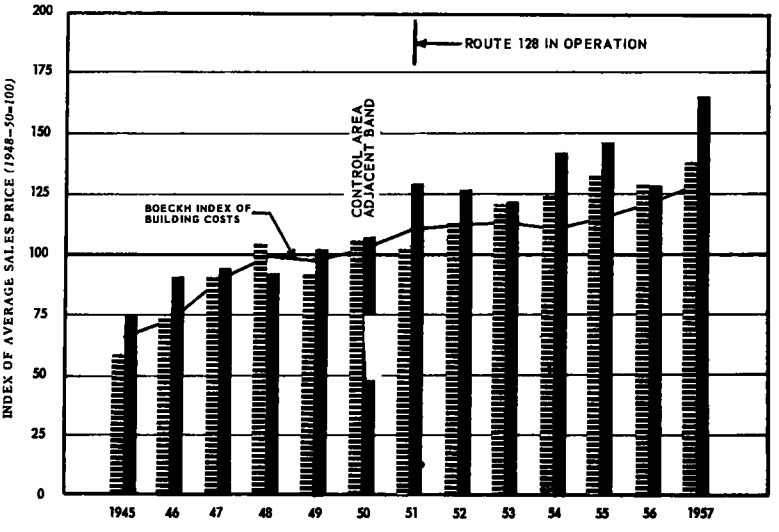


Figure 17. Average sales prices of houses built before 1942 in Lexington, Mass.—Index: Adjacent band and control area.

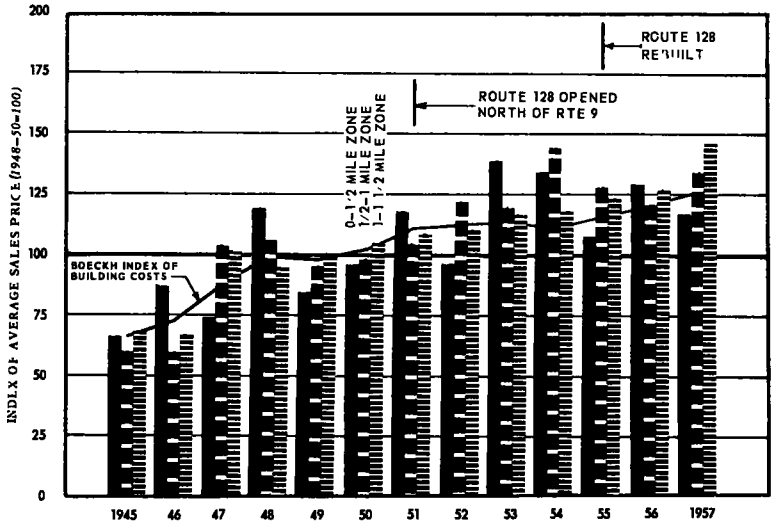


Figure 18. Average sales prices of houses built before 1942 in Needham, Mass.—Index: Access distance zones.

The house density trends in the three access-distance zones in Needham are shown in Figure 14. Indices are in Figure 15. The same upward trend appears in the 0-½ mile zone, although less marked than in Lexington. However, after 1952 the rate of increase in all zones was the same. In making comparisons between Figures 13 and 14, the curves in Figure 14 should be moved mentally to the right about a year, since house densities in Needham were compiled from building permits, which usually precede occupancy permits (used in Lexington) by one or two calendar years.

Average Prices of Houses

Number of sales annually and average sales prices were obtained for new houses

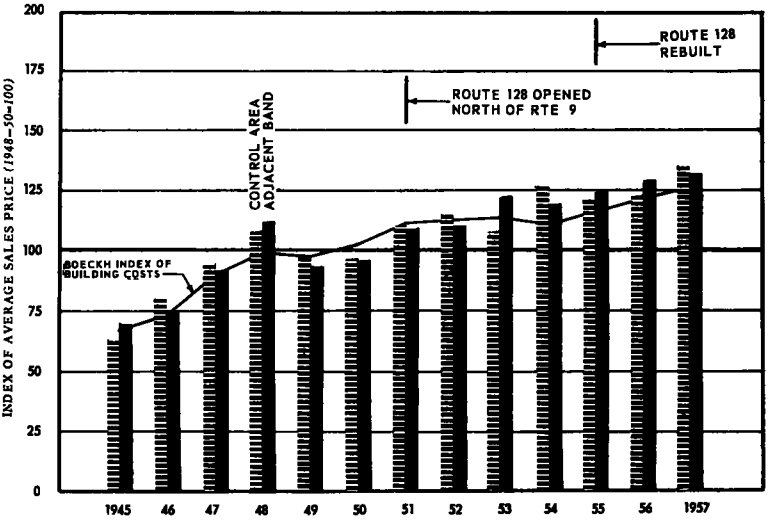


Figure 19. Average sales prices of houses built before 1942 in Needham, Mass.—Index: Adjacent band and control area.

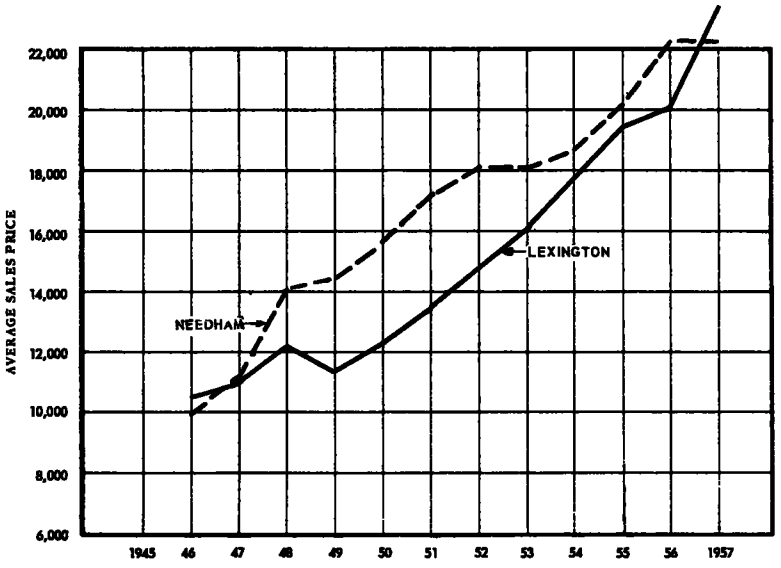


Figure 20. Average first sales prices of new houses in Lexington and Needham.

and old houses in the several study areas. In this paper, indices of average sales prices are shown for old houses only; that is, those in existence in 1942. Since no building of any consequence took place during World War II, the same number of houses existed in 1945. The prices, therefore, apply to resales of residential properties during the period 1945-57.

The Boeckh index of residential building costs in Metropolitan Boston has been added to all sales price index graphs to denote the inflationary trend. Prior to 1951 average sales price indices followed this index fairly closely, since then they have been above it.

In Lexington the trend has been for average sales prices to increase more rapidly in the adjacent band than in the control area (Fig. 17). In the three access zones the upward trend is more variable, the prices in the 0-½ mile zone are sometimes above

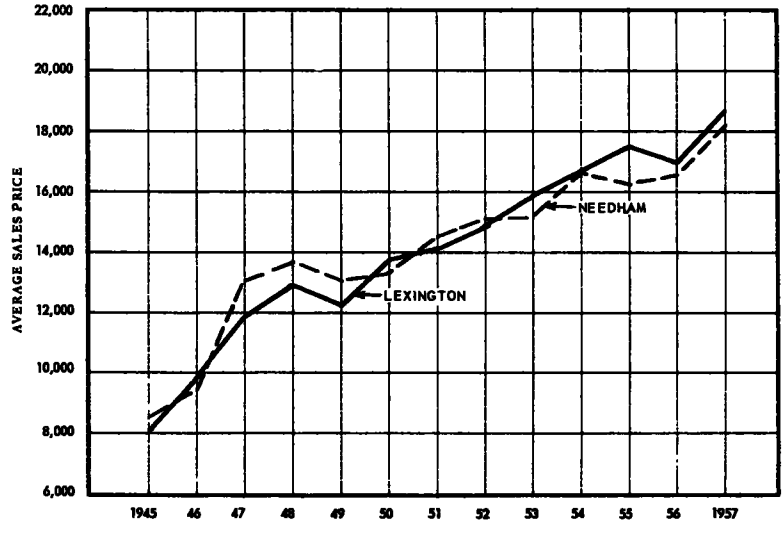


Figure 21. Average sales price of houses built before 1942 in Lexington and Needham.

and sometimes below those in the other zones. In terms of actual sales prices those in areas near Route 128 have been generally lower than in the control area, although the trend is for the difference to decrease (Figs. 20 and 21).

In Needham there appears to be no marked difference in average sales price trends in the adjacent band and control area (Fig. 19). In the access-distance zones the trend varies among zones. In 1951, 1953, 1954, and 1956 the greatest increase was in the 0-½ mile zone, but in other years since 1950 it was greater in the other zones.

The average sales prices in Needham were somewhat higher in the adjacent band and in the 0-½ mile zone than in the control area or in other zones (Figs. 20 and 21).

Figure 20 shows average first sales prices of new houses in Needham and in Lexington. Figure 21 shows similar data for old houses. Two trends are apparent: the prices of new homes have risen faster in Lexington than in Needham, and are nearly the same in 1957; the prices of older houses have risen about equal amounts in Lexington and Needham.

Since 1950 the index of average sales prices of old houses tends to be above the Boeckh index, particularly in Lexington, indicating a greater price rise than might be expected from inflation alone. This rise above the Boeckh index is more marked for average new house sales than for old house sales. A number of causes are suggested for this trend, such as increased development costs due to larger lot size requirements, better quality of house, and certain environmental factors attracting home seekers to Lexington and Needham. These factors appear as strong in areas near Route 128 as in those farther away.

Trends in Towns on or Near Route 128

A study was made of building permits issued and population trends in towns adjacent to Route 128 and outside of Route 128. For this purpose, each of the two above groups of towns were divided into three classes: towns on radial highways of high traffic, medium traffic and low traffic volume respectively. The results indicated a greater acceleration since 1950 of building activity and of population movement into towns having the lowest volume of radial traffic in 1950. In other words, a filling in of areas between major radials is taking place. For example, the net migration into towns on Route 128 that have least adequate radial highways increased 310 percent in 1950-55 over 1945-50, compared to an increase of 145 percent between the same periods in similarly located towns outside Route 128. Migration into suburban towns has been accompanied by migration out of Boston proper and the other centrally located towns. Since 1945 this outward migration has amounted to about 175,000 people. Although this type of growth might have been expected as a normal result of suburban expansion, there is evidence that Route 128 is a contributing factor since it provides an ease of access between radial highways which did not formerly exist.

COMMENTS ON IMPACT STUDIES

Most highway impact studies are limited in scope, considering only a few miles of highway and only a few indicators of impact, such as real estate activity and volume of retail sales. In this study substantial length of highway was investigated and an effort was made to relate the impact of the highway to the entire metropolitan area. Possible losses in investment and employment in places vacated by industries moving to Route 128 were considered as well as gains on Route 128. The motives behind the move of industries to Route 128 and the impact of land use changes on the use of the highway were investigated. The latter effect has been neglected in most impact studies.

As the study progressed, it became increasingly apparent that highway impact is a result of many factors, and is not limited to a specific area near the road. The net effect on the economy of the region in which the highway is located is important.

Whether a new highway attracts or stimulates development, depends upon the demand which exists in the region for such development. If there is no compulsion for industries to expand and move, or if there is no potential for new businesses to be started, little development except the usual gasoline stations, motels and restaurants can be expected along the highway.

Factors, such as the above, need to be evaluated before predicting future development along a proposed highway, forecasting future traffic or applying the results of experience observed in one area to another area of different characteristics.

In the residential phase of this study, considerable research was expended in exploring the use of different statistics or "indicators" of residential growth, and in selecting different types of study areas, both with respect to proximity to the highway and ease of access to and from interchanges. The distance-access zone method, based on travel distance from the nearest interchange, appears more logical than the adjacent band and control area method, especially for application to a controlled-access highway. However, in that method one is confronted with study areas of different sizes. In future studies it is suggested that serious consideration be given to dividing the region through which the road passes into units or sectors, and obtaining basic data for each unit. These units should preferably be of about equal area but not necessarily of regular shape. In a place where streets are laid out in a rectangular pattern, a grid system might be possible. In New England towns, such as Needham and Lexington, which have irregular street systems, varied land use and varied topography, the gathering of data would be expedited by selecting unit areas that conformed to street layouts and land uses. For each unit, such characteristics as zoning class and land available for development would be recorded as well as selected indicators of industrial and residential development. The objective would be to find out what was happening and where. No predetermined influence or control area would be set off, although the units could be assembled in any combination desired; in a band along the highway, in distance zones from an interchange, or according to some indicator of impact such as a selected percent increase in development over a former year. In this report town-lines were used as limits of study areas for the sake of convenience in obtaining data. In the sector method town boundaries might be conveniently used for dividing units, but they should not serve as boundaries of the system of units. The extent of the system would be determined by practical considerations, but, in general, it should extend beyond the areas of probable influence. The analysis of these data, however, would only provide information on where and how much residential development is taking place. The importance of the extent of the influence of the highway would still be unanswered. Seemingly, researchers would have to supplement the data analysis with home-owner and sub-divider interviews for this latter answer.

Machine computations would be a must for such a system of data analysis. The collection of data should be planned so that it could be tabulated directly by a coding system suitable for machine processing. In order to minimize the labor of obtaining basic statistics, thought should be given to the selection of the most reliable and most readily available indicators of residential and industrial growth that can be found in the area where the study is to be made. Once this basic data has been obtained and processed, a wide variety of analyses can be made in little time and at low expense using computers.

In this report residential and industrial development were studied separately and brought together for evaluation of the net influence on communities. This separation was made largely for convenience, and also because in the case of Route 128 the industrial development was more obvious than the residential. In the unit system a segregation within study units by land-uses would be necessary for analysis purposes.

Certain additional questions would have been desirable in the industrial questionnaire. Management was asked why they chose their site on Route 128. The answers usually also implied why they left their old sites. However, a positive question directly asking why they left their old sites would have been better. From this information a more direct evaluation could have been made of the motives behind their move to Route 128. Additional questions should have been asked retarding the old site, such as, investment in old plant, taxes paid, floor space, and amount and adequacy of parking space. Dollar volume of business at old and new sites would also have been useful.

CONCLUSIONS

The principal impact of Route 128 has been the channeling of industrial development into the towns through which it passes. Residential development has also been stimulated in areas along the highway, particularly near interchanges.

The new tax revenue derived from industrial development on Route 128 has helped towns meet a part of the rising cost of municipal services that would otherwise be borne by home owners.

Route 128 industries have provided job opportunities in excess of those offered at former sites.

The attractive character of Route 128 plants has preserved the residential tone of communities. An up-grading of residential property value is noted in areas near Route 128.

Need for accessibility, land for expansion and modernization, adequate labor market along with the desire for an attractive site, were the most important factors behind the move of companies to Route 128. Regional access, free of traffic congestion so typical of in-town locations, appears as a principal reason for the choice of a Route 128 location in preference to alternate sites.

The progress of industrial development is closely related to both the highway completion schedule and zoning law changes. As the centrally located sites become filled, growth may be expected to spread along the highway. No end to the development appears in sight. New projects on Route 128 are continually being proposed and implemented.

ACKNOWLEDGMENTS

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Our deepest appreciation goes to the management staffs of companies and employees for their fine cooperation in providing the basic information for the [illegible] and travel-pattern phases of the study.

Credit is also due to Russell Larson of the M.I.T. research staff who was responsible for the residential phases of the study.

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Land Value Impacts of Expressways in Dallas, Houston and San Antonio, Texas

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This paper is drawn from recent economic impact studies in the three largest cities of Texas. One study regarding Houston's Gulf Freeway was updated in 1957. The other two studies (Dallas and San Antonio) were conducted in 1957 and 1958.

The three studies used comparable approaches as well as two common methods of analyzing real estate sales data. The approach for each study involved the before-and-after concept, with control areas employed to isolate or infer net expressway effects. One common treatment of sales was to remove the value of improvements on property sold. Each study also presented measurements based on unadjusted sales data.

A variety of situations was analyzed in the three studies. The Dallas and Houston studies were concerned with impacts of expressways having continuous frontage roads. The San Antonio expressway, on the other hand, furnished frontage roads to only 18 percent of abutting lands. The expressways in the three cities traversed areas which include a great number of land use patterns.

Whereas, the comparisons of expressway impacts in the Texas cities offer some interesting and useful confirmations and contrasts, an equally important feature of this paper is its discussion of the methods used. The strengths, weaknesses and uncertainties of the before-and-after approach and its associated techniques are appraised. Suggestions for using and improving the scheme also are presented.

● THIS paper is based on recent economic impact studies in Texas' three largest cities. Two of the studies, those in Dallas and San Antonio, were completed by the Texas Transportation Institute in 1957 and 1958. The third study, which had Houston's Gulf Freeway as its subject, was conducted in part in 1951 by Norris and Elder, Consulting Engineers for the Texas Highway Department, and the U.S. Bureau of Public Roads. The same firm updated the Houston study in 1957.

The primary purpose of this paper is to review the findings of the three Texas studies regarding the influence of expressways on land values. In support of this purpose, some references are made to impacts on land use and business. Another general objective is to spell out some of the limitations of the approaches used in the studies, with special emphasis on the hazards of using real estate sales to measure land value changes and expressway effects. The three studies used highly comparable approaches as well as two common methods of analyzing the effects of the expressways on land values.

The approach of each study involved the "before-and-after" concept with comparative control areas employed to isolate or infer net expressway influences. More precisely, the selected area along each expressway was regarded as the experimental group and the comparable area that was presumed to be unaffected by the expressway was considered the control group. The aim was to establish the fact of causation, with an expressway introduced as a factor of the experimental group only. Differentials of change in the two groups presumably would be due to the expressway's effect, if it appeared

reasonably certain that no other factor had caused such differentials. The problem of assuring the absence or sameness of factors other than an expressway is crucial and difficult. It will be given consideration later in this report.

The Houston, Dallas and San Antonio studies sought to measure land value impacts through analyses of real estate sales[1]. One of the common methods or treatments of sales prices was to remove the value of property improvements from price considerations. This was done by subtracting from the sales price the appraised tax value of improvements multiplied by a construction cost factor. The remaining consideration should reflect more closely the portion of the purchase price paid for land only. The construction cost factor was applied in an attempt to adjust tax appraisals, which are of a certain past date, so that they would reflect the market value (or depreciated replacement cost) of improvements at the date of the property sale. The other method common to each study was the use of sales prices as they occurred. Both of the common methods are laden with shortcomings, some of which are later discussed.

It is not practicable in this paper to describe fully the environments of the three subject expressways. Perhaps a few observations regarding the three cities and the specific areas traversed by the expressways will furnish a sufficient framework, however, for a discussion of their economic impacts.

The populations of Houston, Dallas and San Antonio were each well above 500,000 at the time of the expressway studies, as shown in the following listing:

CITY	POPULATION[a]	
	1950	1957
Houston:		
City	596,163	872,000
Metropolitan Area	806,701	1,136,000
Dallas:		
City	434,462	621,500
Metropolitan Area	614,799	827,500
San Antonio:		
City	408,442	545,000
Metropolitan Area	500,460	710,451

[a]Source: Texas Almanac, 1958-59, The Dallas Morning News, Dallas, Texas.

Each city experienced sizeable population growth from 1950 to 1957. Houston, the largest of the three, now has more than 1,000,000 residents in its metropolitan area while the Dallas and San Antonio metropolitan areas have populations of more than 800,000 and 700,000 respectively.

Houston may be characterized as an industrial city. However, its wholesale sales at three billion dollars annually are about double its retail sales. Complementing its position as a great trading center, Houston has the second ranking port in the United States from the standpoint of tonnage.

Dallas may be regarded primarily as a trade center, although its manufacturing activities also are very important. The city exceeds Houston in wholesaling and also is a leader in banking, general finance and insurance.

San Antonio is a very old city. Its highly diversified income is derived largely from agriculture, military establishments, medical services and tourist trade. Manufacturing, although important, accounts for only 12 percent of the city's employment.

[1] In addition, the Houston Gulf Freeway study reported some tax information and the Dallas North Central Expressway study included detailed analyses of the expressway's effects on tax valuations of land and improvements.

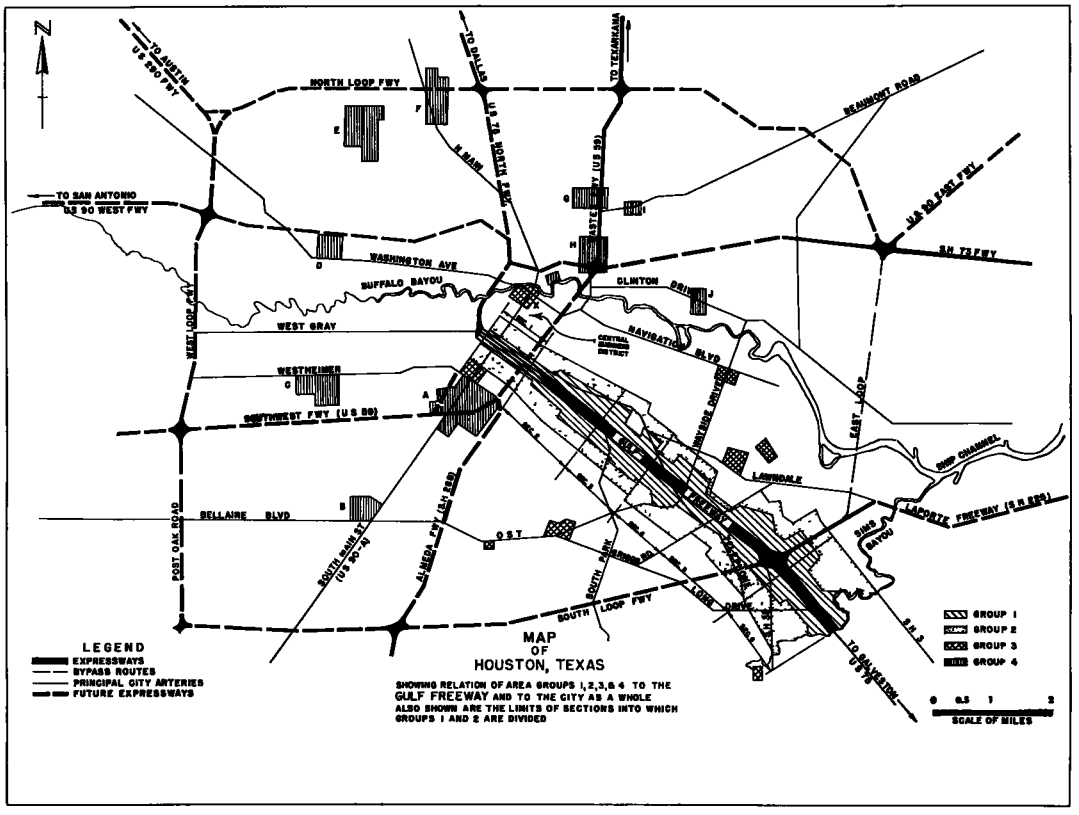


Figure 1. Study of land values and land use along the Gulf Freeway.

The three cities have demonstrated dynamic growth characteristics. Their boundaries are reaching out and their projected populations reflect still greater expansion. Each of the expressways studied was the first limited-access facility in its particular city. The expressways have the further similarity of having been located in older urban areas.

All of the expressways cut across areas of low-cost and middle-class dwellings, retail and commercial establishments, and manufacturing. The areas adjacent to the Houston and Dallas expressways had fairly high proportions of vacant land. In Dallas, about half of the area of abutting properties was unimproved. In San Antonio, a relatively small amount of the land in the selected influence area was unimproved, probably less than 20 percent.

TABLE 1

CHANGES IN LAND VALUES ALONG THE GULF FREEWAY, HOUSTON, TEXAS AND IN OTHER AREAS OF THE CITY 1939-41 TO 1954-56 (1)

	Method 1	Method 4
	Unadjusted Sales Prices	Value of Land Only[1]
	Percentage Change	
Group 1 — Study Area	585	567
Group 2 — Study Area	242	142
Group 4 — Control Areas	251	103
	Inferred Gulf Freeway Influence	
Group 1	334	464
Group 2	-9	39

[1] "Sales Prices with improvements deducted on the basis of assessed value divided by the appropriate assessment factor and the factors based upon the increase in construction cost." Norris and Elder, op. cit., p. 62.

THE HOUSTON GULF FREEWAY STUDY (1)

Definite plans for the Gulf Freeway were developed in 1943. Construction was started in early 1946 and a three-mile section was placed in operation in 1948. The study areas for the economic impact study were along the six and one-half miles in operation in October, 1951. The freeway, which begins

TABLE 2

CHANGES IN LAND VALUES IN STUDY AND CONTROL AREAS, GULF FREEWAY STUDY 1939-41 TO 1945-46

	Method 1	Method 4
	Unadjusted Sales Prices	Value of Land Only
	Percentage Change	
Group 1 — Study Area	94	126
Group 2 — Study Area	54	22
Group 4 — Control Areas	90	130
	Inferred Gulf Freeway Influence	
Group 1	4	-4
Group 2	-46	-108

TABLE 3

CHANGES IN LAND VALUES IN STUDY AND CONTROL AREAS GULF FREEWAY STUDY (1) 1945-46 TO 1954-56 (1939-41 = 100 PERCENT)

	Method 1	Method 4
	Unadjusted Sales Prices	Value of Land Only
	Percentage Change	
Group 1 — Study Area	491	441
Group 2 — Study Area	188	120
Group 4 — Control Areas	161	-27
	Inferred Gulf Freeway Influence	
Group 1	330	468
Group 2	27	147

near the central business district, was opened all the way to Galveston in August, 1952.

The before period used in the study was 1939-41 and prices were also studied in the 1945-46, 1949-51 and 1954-56 periods. Although the facility was definitely planned in 1943, its influence probably began in 1945 when its route was definitely established. Except for an eighteen block section consisting of four one-way streets near downtown Houston, the facility has six free lanes plus frontage roads (Fig. 1). These frontage roads are continuous except at railroad crossings.

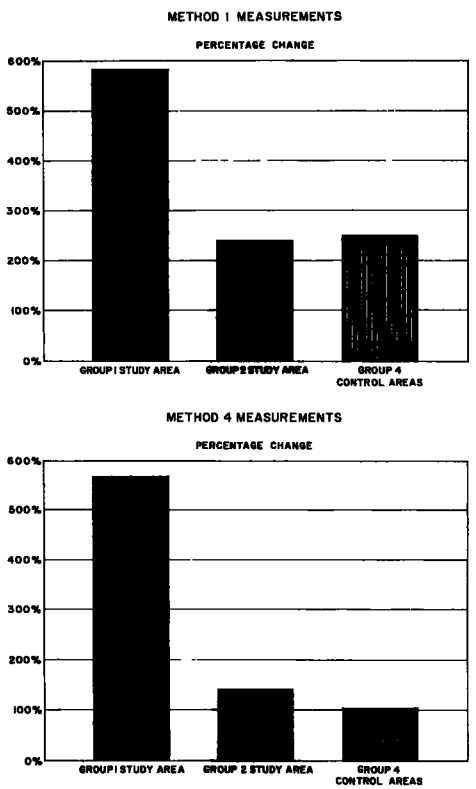


Figure 2. Houston changes in land values along the Gulf Freeway and in control areas 1939-41 to 1954-56.

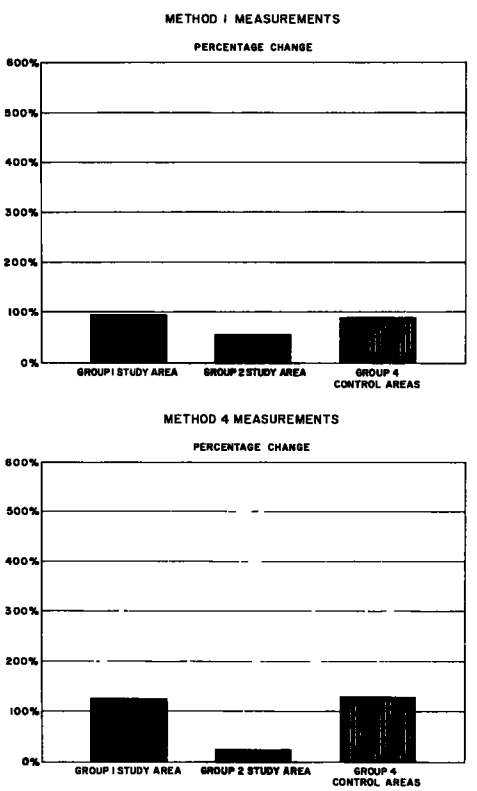


Figure 3. Houston changes in land values along the Gulf Freeway and in control areas 1939-41 to 1945-46.

The areas studied in Houston may be identified as follows:

Group 1—Immediately adjacent to the freeway, was comprised of bands two to four blocks in width on each side of the facility. Thus, the group included properties other than those abutting the freeway.

Group 2—Was the secondary area paralleling the freeway on either side and adjacent to Group 1. These Group 2 bands also varied from about two to four blocks in width.

Group 3—Areas were in the same (southeast) quadrant of Houston as the facility but not in bands like Groups 1 and 2. Findings regarding Group 3 are not included in this paper.

Group 4—Included ten areas selected for their similarity to parts of Groups 1 and 2 but located outside any possible zone of influence of the freeway. Group 4, therefore, is the control group for experimental Groups 1 and 2.

Tables 1, 2 and 3 summarize the findings of Norris and Elder regarding land value changes in the study and control areas. Only Method 1 and Method 4 results are shown because these same methods were used in the Dallas and San Antonio studies. As is shown in Table 1, the area immediately adjacent to the expressway experienced a much larger increase in land prices from 1939-41 to 1954-56 than did Groups 2 and 4. This was indicated by both methods. Method 1 measured a 585 percent increase in property prices in Group 1 and a 251 percent increase in control areas. Thus, the inferred freeway influence on Group 1 property prices was therefore 334 percent. (It should be noted that this net influence was calculated for the purposes of this paper and not by Norris and Elder in their report.)

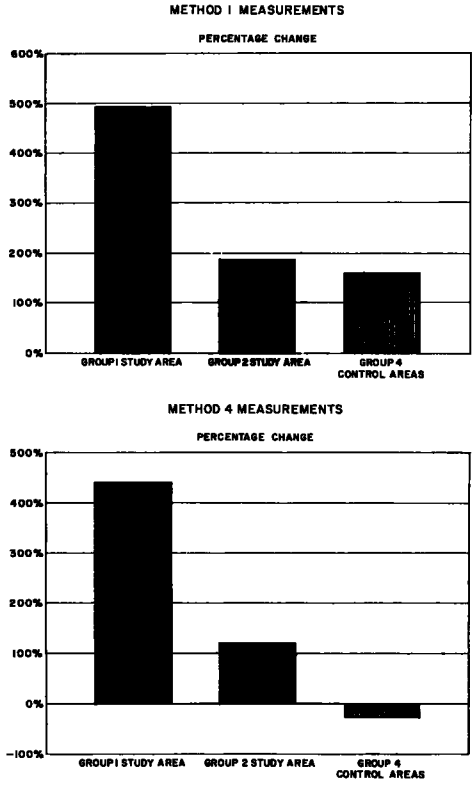


Figure 4. Houston changes in land values along the Gulf Freeway and in control areas 1945-46 to 1954-56 (1939-41=100%).

According to Method 1 computations, Group 2 did not fare as well as the control areas; the inferred freeway influence being a negative nine percent. Method 4 measurements inferred a freeway influence of 464 percent on Group 1 land values and 39 percent on land values in the Group 2 study area.

The type of question that arises immediately is this: Is the 39 percent differential indicated by Method 4 for Group 2 significant, or is it due to the lack of similarity of study areas and control areas? Is it due to poor representativeness of sales in either control and/or study areas in either or both periods of sales? Was it caused by bias inherent to Method 4? Note that the size of 39 percent (relative to the very large impact implied for Group 1 properties) is the factor that suggests these questions. The same questions are suggested regarding the negative nine percent shown by Method 1. They do not appear to be of great importance when the rather large measurements of the impact on Group 1 are being considered.

Perhaps some additional light may be shed on these questions by inspecting measurements of the Gulf Freeway's influence over shorter periods of time. Table 2 shows changes in value in study and control areas from 1939-41 to 1945-46. (Recall that the freeway probably became a factor of influence in 1945.) The first conclusions are that the freeway had very little imme-

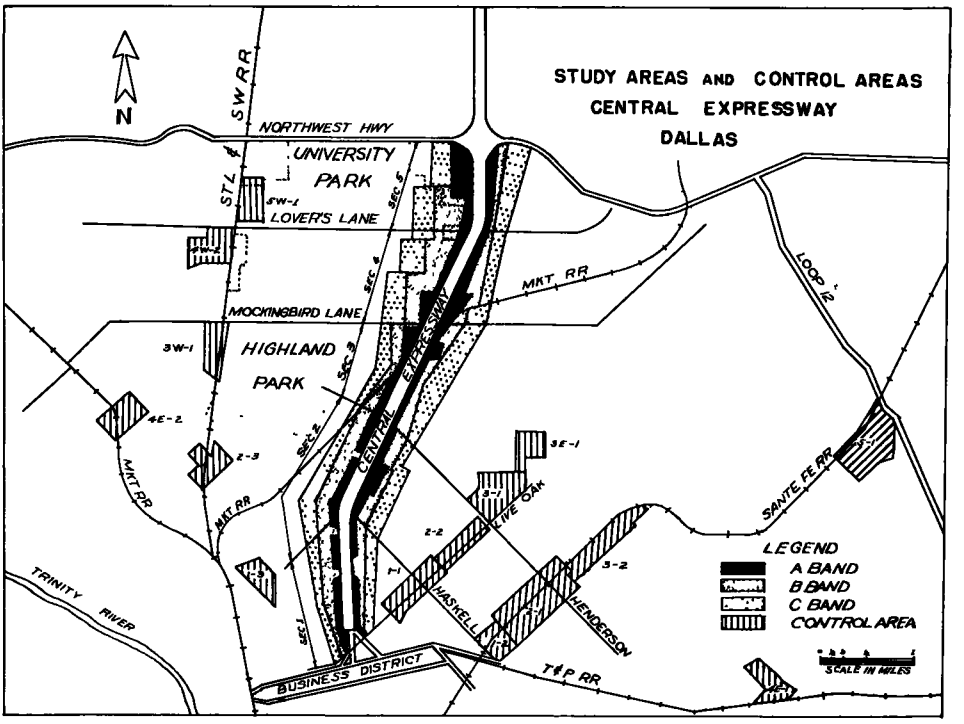


Figure 5. Study areas and control areas central expressway Dallas.

diate effects on Group 1 property values but seemed to have damaged the more-removed properties in Group 2. Both methods of measurement seem to indicate this conclusion. Are these inferences consistent with a logical pattern? Perhaps the more distant Group 2 areas felt apprehension on the part of buyers and sellers that the value of land would be drained away to Group 1. However, Group 1 buyers and sellers apparently did not anticipate that values would accrue (from anywhere) to Group 1.

It seems more logical to assume that the areas immediately adjacent to the proposed facility might fall in value whereas the areas further removed would experience very few immediate expressway effects. Questions regarding the precision of sales prices in measuring land values come to mind again.

TABLE 4

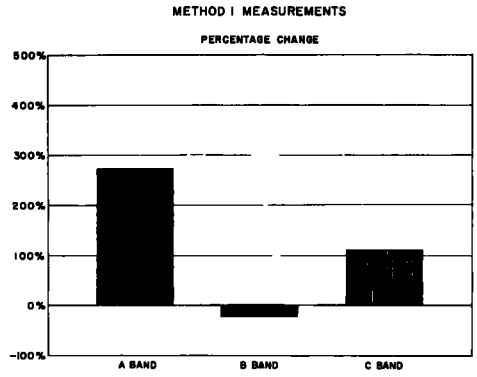
CHANGES IN LAND VALUES ALONG THE NORTH CENTRAL EXPRESSWAY, DALLAS, TEXAS, AND IN OTHER AREAS OF THE CITY 1941-45 TO 1951-55 (2)

	Method I	Method II
	Unadjusted Sales Prices	Value of Land Only[1]
	Percentage Change	
A Band Study Area	405	623
B Band Study Area	110	123
C Band Study Area	231	185
Control Areas, Respectively	134 132 121	140 123 127
	Net Influence of the Expressway	
A Band	271	483
B Band	-22	0
C Band	110	58

[1] Method II removed from sales prices the value of improvements, calculated as their tax appraisal value multiplied by a construction cost factor.

Table 3 shows that the enhancements which might be accorded to the freeway apparently occurred after 1945-46. During this period, the inferred Gulf Freeway influence was beneficial in both Groups 1 and 2 study areas. Method 4 measurements show increments of 468 percent for Group 1 and 147 percent for Group 2 on the basis of 1939-41 land prices. The size of these indicators of influence quiet some of the doubts raised in earlier questions but do not, of course, answer them.

It should be emphasized that only a part of the findings of the Gulf Freeway study has been dealt with here. Such extractions from a study face the hazard of being misused and misinterpreted. The investigator



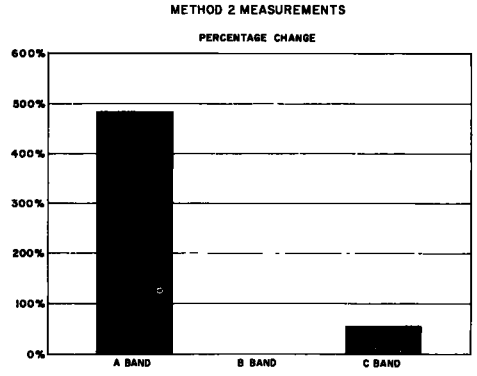
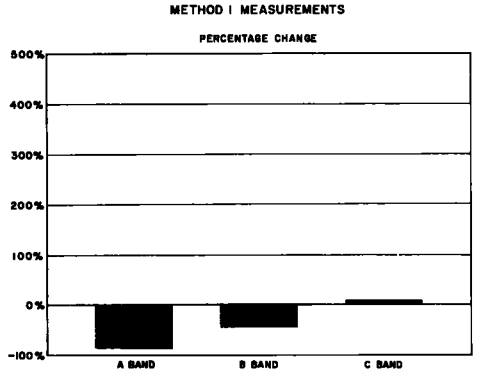


Figure 6. Dallas net influence of central expressway on land values of adjacent areas 1941-45 to 1951-55.



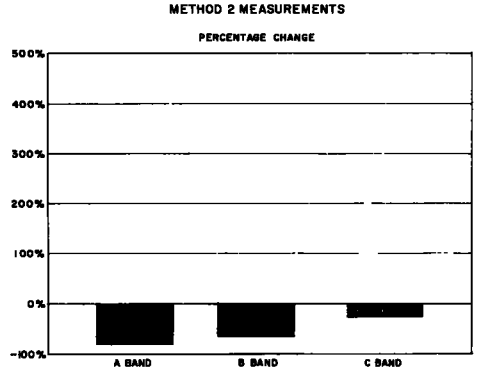


Figure 7. Dallas net influence of central expressway on land values of adjacent areas 1941-45 to 1946-50.

is in the best position to develop conclusions in view of his experience and his complete analysis of findings. The questions raised here are concerned with the tools and materials available for use in land values research. The Dallas and San Antonio Studies are subject to the same, and other questions.

THE DALLAS CENTRAL EXPRESSWAY STUDY (2)

Like the Gulf Freeway, Dallas' Central Expressway, or other type of major thoroughfare on the same route, had been contemplated for several years before it became a reality. Definite planning for the Dallas facility was not begun until late 1945, however. Initial construction was started in 1947 and the first section of the expressway was completed in 1949. The portion of the expressway chosen for study was opened to traffic in its entirety in early 1953. This portion is 5.4 miles in length from near downtown Dallas to the Northwest Highway, a circumferential route. Findings presented in this paper, however, relate only to a stretch of about 4.4 miles which may be called the older urban part of the study area.

The subject expressway has six free lanes for 3.6 miles and the remainder has four

TABLE 5

CHANGES IN LAND VALUES IN STUDY AND CONTROL AREAS, NORTH CENTRAL EXPRESSWAY STUDY 1941-45 TO 1946-50

	Method I	Method II
	Unadjusted Sales Prices	Value of Land Only
	Percentage Change	
A Band Study Area	8	56
B Band Study Area	48	58
C Band Study Area	95	97
Control Areas, respectively	95 92 88	136 122 123
	Net Influence of the Expressway	
A Band	-87	-80
B Band	-44	-64
C Band	7	-26

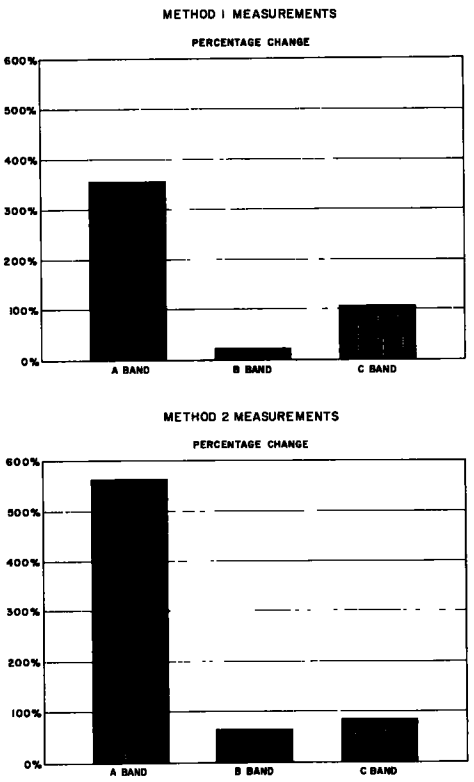


Figure 8. Dallas net influence of central expressway on land values of adjacent areas 1946-50 to 1951-55 (1941-45=100%).

free lanes. Continuous frontage roads are provided except at one railroad overpass. The area excluded from consideration in this paper is located near the Northwest Highway. The expressway's influence on this area was analyzed separately from its influence in the older urban area.

The study area along Central Expressway was divided into three bands, described as follows:

A Band—Which consisted of properties abutting the expressway right-of-way on each side.

B Band—Which was adjacent to the abutting properties and averaged about two blocks in width.

C Band—Which was adjacent to B Band and also averaged about two blocks in width.

Sixteen non-affected or control areas were chosen because of their similarity to various sections in the three study area bands.

Sales data were collected for the years 1941 through 1955. The before period was 1941-45 and the after period was 1951-55. A middle period of sales, 1946-50, was used to check immediate expressway effects. Four different methods of treating real estate sales were presented in the report of the Dallas study. Only Method I and Method II are dealt with in this paper, these being the same as Methods 1 and 4, respectively, of the Gulf Freeway study.

Table 4 shows calculations of Central Expressway's impact on land values in A, B and C Bands up to 1951-55. The size of the measurements obtained by Method I, 271 percent, and Method II, 483 percent, leaves little doubt that A Band properties were enhanced by the expressway, and substantially. Note, however, that the next properties, B Band, apparently were not benefited. Method I indicates that there was a negative effect of 22 percent and Method II measured no differential between land value changes in B Band and its control areas.

The third band of properties was enhanced according to both methods. Is it logical that the expressway's impact leapfrogged from abutting properties to C Band? The most reasonable judgment is that it did not. The explanation of these results must lie in the questions raised earlier regarding the findings in the Gulf Freeway study. In short: Were the data used representative of land values? Were the tools of sales data analysis too dull to measure impact accurately? Were control areas truly comparable to study areas in the before period? Results presented in Table 5 increase the probability of analyzing the questions adequately. Note the similarity of these results with those in Table 2 regarding the Gulf Freeway's early impact.

TABLE 6

CHANGES IN LAND VALUES IN STUDY AND CONTROL AREAS, NORTH CENTRAL EXPRESSWAY STUDY 1946-50 TO 1951-55 (1941-45 = 100 PERCENT)

	Method I	Method II
	Unadjusted Sales Prices	Value of Land Only
	Percentage Change	
A Band Study Area	397	567
B Band Study Area	62	65
C Band Study Area	136	88
Control Areas, respectively	39 40 33	4 1 4
	Net Influence of the Expressway	
A Band	358	563
B Band	22	64
C Band	103	84

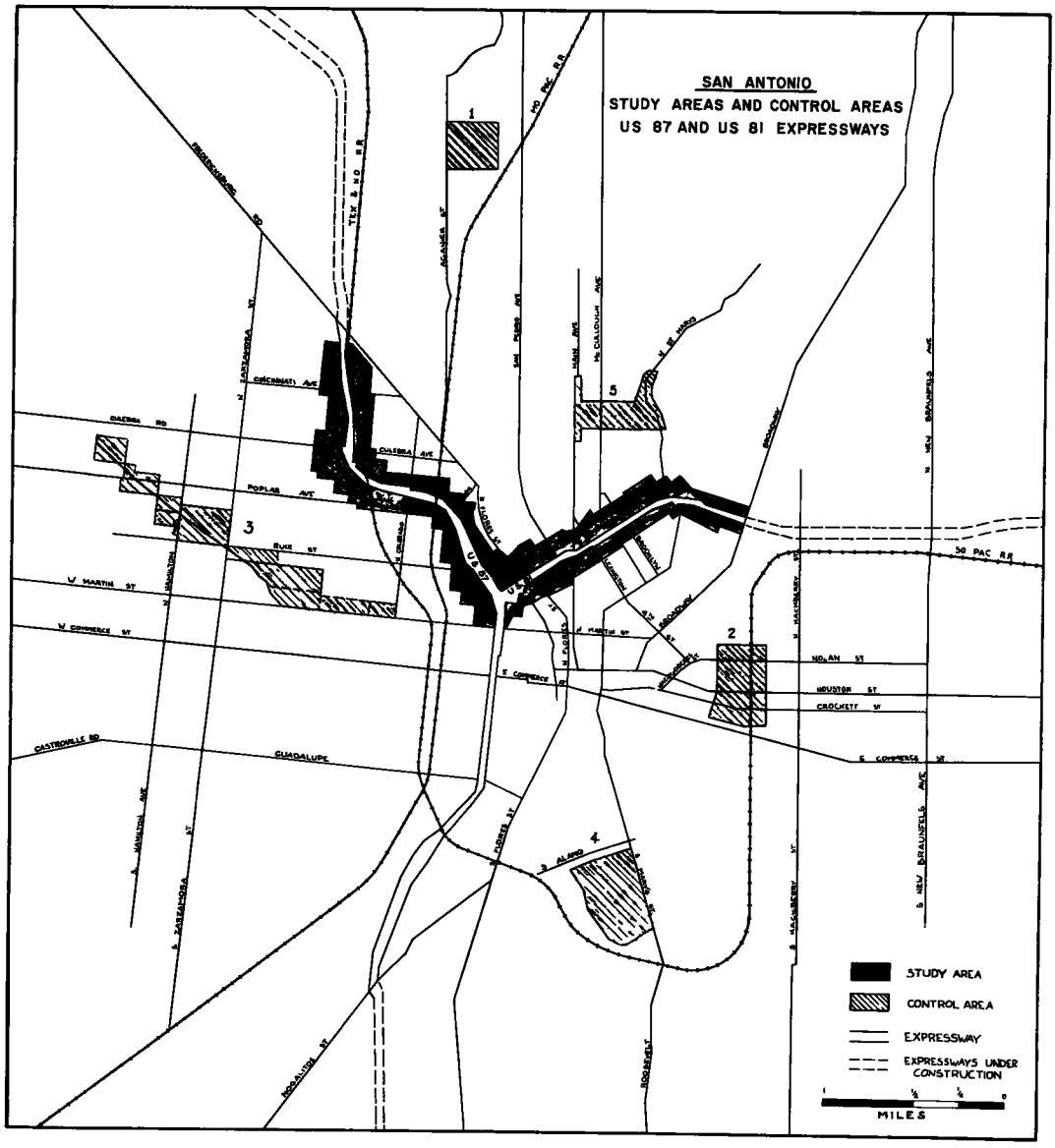


Figure 9. San Antonio study areas and control areas US 87 and US 81 expressways.

Assuming that the influence of Central Expressway commenced in 1946 and, for a moment, that the data in Table 5 are strictly applicable, then the expressway's immediate impact was one of damage to the three study bands. It was found by interview that some uncertainty existed in A Band during the construction and in early years of the facility. This market factor may well have reached into B Band. It could have reached into C Band, but the likelihood is not great.

There is a greater probability that control areas had somewhat more potential for land value increases than study areas. Evidence to this effect, although not in exact degree, was found in the Dallas study. Assuming this to have been true, the control area standards shown in Table 5 were too severe and resulted in overestimates of any expressway disbenefits that occurred. In a different vein but supporting this latter conclusion, it also was found in the Dallas study that properties which sold in A and B

Band study and control areas did not accurately represent the properties in the areas. Further, the lack of representation introduced a bias adverse to the measurement of beneficial effects of the expressway in all time periods in which the impact was calculated.

Table 6 deals with land value changes in the 1946-50 to 1951-55 time period in the Dallas study. The indexes of influence show that A Band was spectacularly benefited. Land values in B Band also were enhanced but not greatly, and somewhat less than those of C Band. The favorable influences of the expressway seem to have been restricted to the 1946-50 to 1951-55 period and more than offset any earlier damages.

TABLE 7

CHANGES IN VALUES OF UNIMPROVED LAND IN STUDY AND CONTROL AREAS, NORTH CENTRAL EXPRESSWAY STUDY 1941-45 TO 1951-55

	Percentage Increases		Influence of the
	Study Area	Control Area	Expressway
A Band	518	150	368
B Band	383	162	221
C Band	291	186	105

Separate calculations of the Central Expressway's impact on values of unimproved land were made. The results for the 1941-45 to 1951-55 period are presented in Table 7. The measurements show that vacant land was benefited 368 percent in A Band, 221 percent in B Band, and 105 percent in C Band. Although not shown in Table 7, the enhancements apparently occurred after 1946-50 since negative influences were calculated for vacant land in all three bands from 1941-45 to 1946-50. Again, the question arises as to whether the expressway damage calculated for the early period was due to a mismatch of study and control areas or to actual disbenefits. The fact that damages were measured for all study area bands in the early period suggests that control areas may have been superior. It cannot be contended from the evidence, however, that the expressway did not have any negative effects in the study areas during the early period.

THE SAN ANTONIO EXPRESSWAY STUDY (3)

The study of expressway effects in San Antonio had as its subject two expressway sections totaling 3.7 miles in length and located near downtown San Antonio. One of the sections is the route of US 81 and the other of US 87. Since the two sections merge,

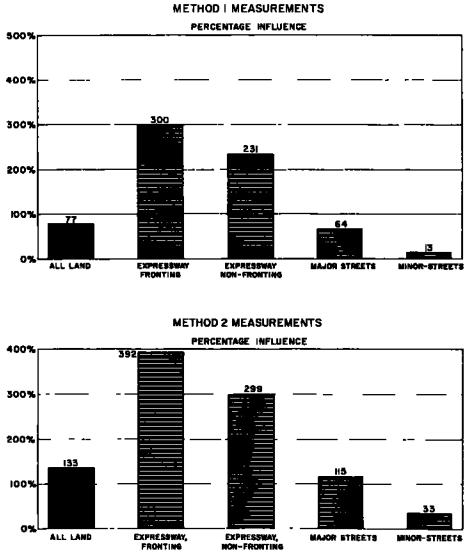


Figure 10. San Antonio expressway influence on values of adjacent lands by type-of-street locations.

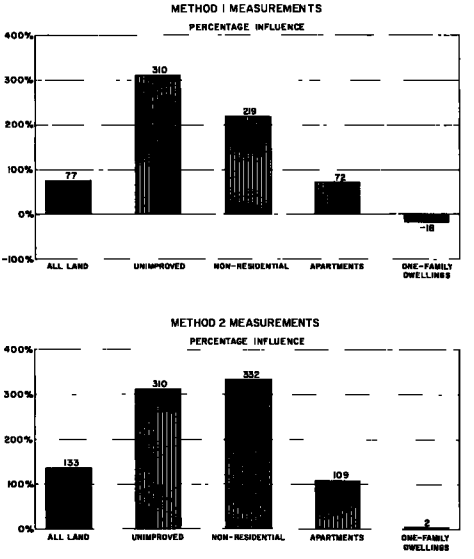


Figure 11. San Antonio expressway influence on values of adjacent lands by land uses.

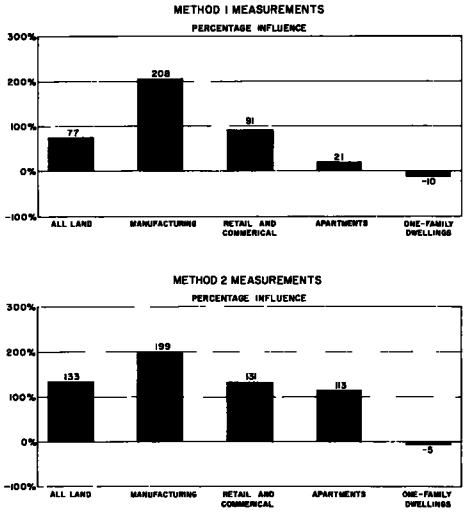


Figure 12. San Antonio expressway influence on values of adjacent lands in various zoning districts.

they were treated as one expressway in most of the study analysis. Along most of their length, the expressway sections have four freeway lanes separated in pairs by a median. One short stretch has six free lanes. Frontage roads are not continuous being limited to about 32 percent of the abutting land.

The before period in the San Antonio study was 1941-45, in view of the fact that definite planning for a part of the expressway had been started in 1946. The after period was 1952-56, although the sections studied were not fully completed until 1954. Five control areas were selected as representative of the area of the city crossed by the expressway sections.

The methods of analyzing sales prices were the same in the San Antonio study as in the Dallas and Houston studies. However, the San Antonio study area was not divided into bands as were the Dallas and Houston study areas. Instead, all properties that sold in study and control areas were classified as to use, zoning and type-of-street location. Analyses then were made of the expressway's impact on various-type properties. This scheme yielded measures of influence on abutting properties, which were called A Band in the Dallas study. Otherwise, no direct comparisons regarding bands of properties are possible for the three studies. Actually, the San Antonio study area has a width about equal to Dallas' A and B Bands combined, being about two to three blocks on either side of the expressway. Along major thoroughfares crossing the facility, an additional two blocks were included in the study area.

Estimates of the expressway's impact on land values in the over-all study area are presented in Table 8. Both Method I and Method II measurements indicate that land values rose more in study areas than in control areas from 1941-45 to 1952-56. The net influence of the expressway was 77 percent under Method I and 133 percent under Method II.

TABLE 8

CHANGES IN LAND VALUES ALONG US 81 AND US 87 EXPRESSWAYS, SAN ANTONIO, TEXAS AND IN OTHER PARTS OF THE CITY (3) 1941-45 TO 1952-56

	Method I	Method II
	Unadjusted Sales Prices	Value of Land Only[1]
	Percentage Change	
Study Areas	164	200
Control Areas	87	67
	Net Influence of the Expressways	
Study Areas	77	133

[1]Method II = Sales prices minus tax appraisal of improvements multiplied by a construction cost factor. The method is the same as Method II of the North Central Expressway study and Method 4 of the Gulf Freeway study.

Table 9 shows calculations of the expressway's influence on land values at different street locations. The greatest enhancement apparently accrued to properties on frontage roads, the benefits being 300 percent by Method I measurement and 392 percent according to Method II. Other abutting properties were benefited seemingly to a substantial degree. The remainder of study area properties received positive but smaller influences especially if they were located on minor streets.

It was found that the use of property conditioned the impact of the expressway. Table 10 shows that unimproved land and non-residential properties were enhanced substantially. Apartments received benefits according to each index. Method I measured damages for one-family dwellings although Method II calculations resulted in small benefits for this class of property.

Another series of measurements concerned the expressway's influence in various zoning districts. Again, a somewhat logical pattern was found (Table 11). Land zoned

for manufacturing was calculated to have received the greatest benefits. Retail and commercial and apartment zoning districts also were enhanced. Areas restricted to one-family dwellings were indicated to have suffered in value from the expressway's presence. The negative influence was small, however, being minus ten percent under Method I and minus five percent under Method II. Again, the question arises as to whether this negative influence was real or a chance product of the study scheme.

Additional analyses of expressway effects on property classified by two or more of the above factors were attempted. The number of sales of more closely defined property types restricted such efforts. It was confirmed, however, that land used and zoned for one-family dwellings and located on minor streets apparently was influenced very little. Properties located on frontage roads were benefited regardless of zoning and use. Land in non-residential uses and zoning districts was calculated to have benefited at all locations.

TABLE 9

INFLUENCE OF THE SAN ANTONIO EXPRESSWAYS ON VALUES OF LAND BY TYPE-OF-STREET LOCATION 1941-45 TO 1952-56

	Method I	Method II
Location of Land	Unadjusted Sales Prices	Value of Land Only
	(%)	(%)
Expressway Frontage Roads	300	392
Abutting Expressway not on Frontage Roads	231	299
Abutting Expressway, all	254	321
Main Thoroughfare, not at Expressway	64	115
Minor Streets, not at Expressway	13	33

QUESTIONS RELATING TO METHODOLOGY

Several questions have been raised in this paper regarding the approach and the methods of sales data analysis used in the Houston, Dallas and San Antonio economic impact studies. These questions were introduced for the purpose of encouraging and soliciting aid in the improvement of economic impact research. Obviously, the examination of findings was not made to discredit them. In the first place, each of the study reports makes objective interpretations of the findings and notes their limitations. Some of the conclusions quite properly were based upon inspections of the study and control areas including observations of land use changes.

TABLE 10

INFLUENCE OF THE SAN ANTONIO EXPRESSWAYS ON VALUES OF LAND IN VARIOUS USES 1941-45 TO 1952-56

	Method I	Method II
Land Use	Unadjusted Sales Prices, %	Value of Land Only, %
Unimproved	310	310
Non-residential[1]	219	332
Apartments[2]	72	109
One-family dwellings	-18	2

[1] Includes local retail, commercial and manufacturing.
[2] Includes duplexes.

Every research effort must be performed within restrictions of time, expense, available skills and, to some extent, proved methodology. It should be remembered also that approaches, methods and techniques adequate for one area do not necessarily lend themselves to ready application elsewhere. Sources of data and their reliability vary from place to place. The cost of research and the size of budget differ from project to project. Furthermore, with any given set of objectives, economic impact studies are extremely complicated. There is a newness about this area of inquiry; even when standard tools and concepts are used there is a newness in terms of their application.

TABLE 11

INFLUENCE OF THE SAN ANTONIO EXPRESSWAYS ON VALUES OF LAND IN VARIOUS ZONING DISTRICTS 1941-45 TO 1952-56

	Method I	Method II
Zoning	Unadjusted Sales Prices, %	Value of Land Only, %
Manufacturing	208	199
Retail and Commercial	91	131
Apartments	21	113
One-Family Dwellings	-10	- 5

As is true of most research projects, a study of an expressway's effects could become a full career and perhaps a worthwhile one. Even then, such a study could not be complete in all of its parts. Early studies are likely to have grievous faults which should be considered as opportunities for improvement rather than for destructive

criticism. Some valuable economic impact data have been assembled. The aim now is to assure a continued increase in their quality.

The remainder of this paper is concerned with but a few of the problems encountered in measuring the effects of expressways on land values. Attention is given primarily to the schemes employed in the Texas studies and to the use of real estate sales data to obtain estimates of land value. The topics to be discussed are as follows:

1. What recommends the "before-and-after" approach?
2. How good are control areas?
3. What do sale prices measure?
4. What do the "Texas" methods measure?
5. What measurements are needed?

These topics are only examples of the many considerations that should receive deliberation. Admittedly, they receive only a superficial examination in this paper. Time limitations make a more searching treatment impractical.

The "Before-and-After" Approach

The advantageous features which recommend the "before-and-after" approach are that it is easy to understand and apparently simple to apply. Certainly, most readers may be expected to understand the procedure of a before-and-after study. Whether or not they accept the findings at at face value is another matter.

The apparent simplicity of using the approach is quite deceptive, however. Since most observations must be made over a period of time, many factors other than a road improvement are likely to influence the study area. Very few such factors are identifiable and also measurable so that their influence may be known and thus controlled. Another difficulty arises in most economic impact studies because the research is conducted in the after period. This aggravates the problem of determining the nature of study areas in the pre-road period.

Would a multiple correlation approach escape the pitfalls inherent in the before-and-after approach? Would more factors be measurable and more accurately controlled? Would statistical control be understood and does such a design assure more precise and reliable findings? The conclusion is that both approaches face many of the same problems and that a correlation technique would add as many difficulties as it would avoid.

It seems apparent, however, that the before-and-after approach is woefully incomplete unless comparative control areas are used with it. A new problem is hereby added, that of selecting control areas and proving their comparability to study areas in all respects except the presence of an expressway.

Control Areas

In theory, the control group should have been identical in composition and potential to the experimental group in the before or pre-road period. Furthermore, factors at play in one group during the influence period should have been the same as those affecting the other group, except that an expressway was introduced into the experimental or study areas. Such a laboratory situation would control a multitude of factors including many not even identifiable. The difference in land values or other phenomena observed in the two groups over the study period would be strictly attributable to the road improvement.

The paradox that comes to mind is that the goodness of control areas can be proved absolutely only by evaluating the multitude of factors that the scheme is supposed to control so painlessly. Perhaps there is no sufficient answer to this argument, at least in this paper. It is, therefore, circumvented.

An ideal matching of control and study areas will never be obtained. Realistically then, requirements are reduced to the assurance that control and study areas are reasonably comparable and unlikely to have been affected differentially by any factor other than the road improvement. Similarly, the amount of effort to be spent in selecting control areas must be in balance with the over-all research effort and in harmony with specific purposes and objectives.

Real Estate Sales Data

There are very few indicators that may be used to measure land values. Among these, real estate sales prices appear to offer the greatest promise but are not without definite drawbacks. An alternative sometimes used is tax valuations of land. These, however, often lag behind market values by several years and are subject to a variety of mismeasurements.

An appraisal approach might be tried but, in turn, this alternative would be carried out through the use of market data including real estate prices. The derivation of land value effects from an expressway's impact on vehicular costs and travel time holds much promise, at least theoretically, but such an approach would face a wide variety of difficulties of a fundamental nature, including the determination of incidence of benefits. Opinion polls sometimes are useful but they lack the quality of objectivity that is so highly desirable.

Perhaps there are still other alternatives that should be investigated. At the present time, analyses of real estate sales data seem to be the universal choice. Findings based on sales are considered a direct reflection of the public's reaction of land market factors and thus to an expressway. Unfortunately, their universality of acceptance has not yet overcome the myriad of problems that sales data introduce.

A body of technical problems is bypassed if it is assumed that bona fide sales, those reflecting actual market value, have been identified. The next concern is whether properties that sold were representative of the properties that existed in study and control areas and in their various strata.

Ideally, a bona fide sale of each property in each time period is what is needed. This, of course, will not happen and a lesser ideal is substituted for it. A pattern of sales to represent a good sample of land values in each time period becomes the requirement. Since such a pattern may not occur, even this modified requirement is not necessarily fulfilled. Adjustments of sales data must be made and sometimes must take rather abstract forms.

Seemingly, if control and study areas were truly comparable, representativeness of sales would be assured. This does not necessarily follow, especially in the after period. The expressway itself may cause certain types of study area properties to sell, properties unlike those selling in control areas and not typical of properties adjacent to the facility.

If a road improvement has a substantial impact on land values, it is almost a certainty that some properties will be ripened for new uses. Such properties are likely to sell first as it would be coincidental if their pre-expressway owners had the highest interest in succeeding uses. This seems especially true for older built-up urban areas. It also seems logical that properties that are vacant or have relatively inexpensive improvements would be among the first to become subject to succession of uses. From these assertions it may be concluded that properties of less than average value in study areas might be the most likely to sell in the after period. This occurred in Dallas' A and B Bands. There is also reason to believe it may have happened in 1945-46, at least, along Houston's Gulf Freeway.

If, during the same period, average properties are sold in control areas, or at least properties that are superior to those which sell in study areas, the consequent comparison will yield either an underestimate of enhancements, or an overestimate of damages. In fact, entirely fallacious damages might be shown for study areas. This may explain some of the negative measurements found in the Gulf Freeway study in the 1939-41 to 1945-46 period.

The fact that expressways are likely to encourage a succession of uses raises questions as to the nature of the estimates of land value influences yielded by the methods employed in the three Texas studies.

Methods of Analyzing Sales Data

The two methods of treating sales data used in each of the three Texas studies are subject to a variety of criticisms. One of the most important of these is that the methods do not properly measure the value of land that is ripened for supersession of use. This

contention holds even if a representativeness of sales occurs, a condition questioned in the previous section. This is a primary concern of the following discussion.

If a road improvement has an impact on adjacent lands, its effect must either enhance or damage properties in their existing uses or ripen them for a change in use. There was strong evidence that the latter influence was felt by land adjacent to expressways in Houston, Dallas and San Antonio. In fact, new uses for some properties became economically feasible immediately. This is to say that the value of properties in a vacant state became greater than the value of land and pre-expressway buildings together plus the net costs of clearing the land. While other properties would have been ripened toward supersession, it is the case of full readiness that is discussed here.

A purchase price for a property ripe for reuse might well represent little more than the market value of the property in its existing use. The actual value of the land, however, would be the purchase price plus the costs of clearing and waiting minus the salvage value of the building. If the salvage value of the building exceeded the expense of its removal and waiting costs, the unadjusted purchase price of the property would overindicate the value of the land by the amount of the excess. If, on the other hand, costs of clearing the land were greater than the salvage value of improvements, the purchase price would underestimate land value by the amount of the difference.

In control areas, total purchase prices overestimate land values by an amount equal to the full value of improvements. (This assumes, of course, that control areas are not experiencing use succession.) Thus, while prices of properties ripe for supersession in study areas may overestimate land values, the excessive amount will be less than the overestimate made by control area prices. The consequence is that a comparison of changes in untreated purchase prices in study and control areas will lead to an undermeasurement of the expressway impact. This may have been the nature of the Method I measurements, which used untreated sales prices, in the three Texas studies. The bias against expressway enhancements is even greater under this method if sales prices in study areas reflected less than the value of vacant land, that is if the salvage value of improvements failed to pay costs of clearing and waiting.

It is suitable at this point to refer again to Tables 2 and 5. Perhaps the failure of Method I to measure values of land ripe for succession in use accounted in part for the negative influences in the early periods in Dallas and Houston. (Poor matching of control and study areas and lack of representativeness of sales also may have been factors in this regard.) Does Method II (Method 4 in the Houston study) which removes the value of improvements from sales prices, do a better job?

Method II removes the value of buildings from purchase prices to give an estimate of the value of vacant land. In the Texas studies, tax valuations of buildings were employed in this method together with construction cost factors to estimate building value at the date of sale. Proving the adequacy of the components used in Method II is a critical step, but for brevity's sake it is assumed that this task has been satisfactorily completed. The question remains: Will Method II, accurately applied, measure an expressway's impact on land ripened for use succession?

Method II would underestimate an expressway's influence on properties brought nearer to reuse. The subtraction of building values from sales prices in control areas will leave the portion of the price that was paid for bare or vacant land. The removal of building value from sales prices of study area properties ripened for reuse will result in a remainder reflecting less than the value of vacant land. This is true because the total purchase price reflected the value of land in a vacant state. Thus the Method II will aggravate the bias explained regarding Method I or untreated sales prices, especially for cases where total purchase price already reflected less than the value of vacant land.

It should be stated that the larger the expressway's benefits to land the more accurately percentagewise will Method I and II measure them. This follows because the proportion of the total price made up of old building value will diminish with increases in land value. Thus errors arising from the presence of improvements will become a smaller part of the total purchase price.

Suppose that the expressway damages adjacent properties. Will the methods reflect the degree of disbenefit accurately? Method I will again overestimate land value by the

value of buildings in control areas. Land values in study areas also will be overestimated, but the amount is uncertain. If it may be assumed that property damages accrue to land, then the uncertainty is removed; Method I will also overestimate the value of land by the full value of improvements in both study and control areas. Seemingly, then, damages to land would be properly measured; but this is not the case. The method will undermeasure the damage to land values in study areas. This occurs because the absolute damage is measured percentagewise on the basis of the full purchase price during the before period. The accurate percentage damage would result only if the vacant land value in the before period is used in the calculation.

Therefore, Method I cannot be considered a measure of land values but rather a measure of property values. Method II, although designed to reflect land values, accurately measures them only if the purchase price was actually paid for land and buildings, the part of the price paid for buildings being equal to their depreciated replacement cost. In this way, Method II will lead to accurate measurements of damages to land if such occurred.

Perhaps a simple solution is that any method that is used should measure the same phenomenon in both study and control areas. Such a method is yet to be developed. There is little doubt that other methods are needed and that every property that sells must be carefully classified and the purchase price treated with a suitable method in each case.

What Measurements Are Needed?

The types of measurements that should be sought by economic impact research, and the precision of these measurements, depend upon the purposes that should be fulfilled. It is fruitless to search for proof that "something" happened. In many instances, this conclusion can be reached by a casual drive along a new facility. Rather, the aim should be to determine what happened, the magnitude of the effects and an explanation of the processes whereby the changes occurred. The implications of the impact also should receive careful attention.

To assure properly conceived research and adequate measurements, the persons who profess the need for answers should express their purposes precisely. Through this device, they can better exploit economic impact research. On the other hand, researchers must seek to base their objectives on the problems of the ultimate consumers of the information. If appropriate tools and methods are not available, it is the obligation of researchers to develop them. Perhaps it is this latter task that makes economic impact research the challenging area of inquiry that it is.

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Approaches to Three Highway Impact Problems

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● THE ACCELERATED development of highway transportation facilities will most certainly introduce marked changes into urban, suburban, and rural life. One is traveling farther, more frequently, and for more varied purposes than before, so the range of distance over which day-to-day travel occurs is being extended, and activities consuming transportation are organized at larger and more efficient levels. An example of the latter is the growth of specialized services using highway transportation to serve customers dispersed through large areas.

Curiosity is widespread about the results of these accelerated transportation developments. For instance, knowledge is needed for both public and private investment decisions, for the formulation of planning policies to insure orderly development of areas served by new facilities, and the formulation of taxation policies. Competition by government services for tax revenue is very keen and many states are pressed for funds to match federal participation in highway construction. Too, the Federal Government is now participating actively in highway user taxes and this requires consideration of highway tax revenue sources at each level of government.

A number of studies of the economic impact of highway improvements have been made in response to these needs for knowledge. A review of completed studies (1) reveals that greatest interest has been in the impact of improvements on business sales and land values in nearby areas. Some of these studies have supplied general information in local areas. Other studies were intended to assist in right-of-way acquisition (2, 6). Also, it is well known that a number of studies are under-way or have been recently completed relating to Section 210 of the Highway Revenue Act of 1956. These studies emphasize relevant criteria for the evaluation of nonuser benefits from highway improvements and the estimation of such benefits. The ensuing paper reviews research (3) on nonuser benefit questions. There are implications from the research for the topics identified earlier, however, because there is a great deal of overlap among impact questions.

The research is reviewed from the standpoint of objectives, methods, and implications. Research objectives and implications will be discussed in some detail, but methods will be sketched only briefly. Thus, stress will be on the point of view (objectives) and fruitful directions of research (implications) rather than on the technical organization and particular findings of the studies.

By way of introduction, contents of the studies and the questions the studies attempted to answer are described briefly as follows:

1. A study of changes in retail business structure resulting from improvements of highway facilities. Structure refers to the spatial layout of the entire urban retail business activity. The question was: How does a complex competitive activity adjust to changes in transportation facilities?
2. A study of variations in household travel patterns associated with variations in available transportation facilities. Particular attention was given to travel for shopping purposes, and to travel as it relates to the selection of the residential site. Two questions were asked: (a) How does a transportation improvement vary the amount and kind of travel from households and, thus, relate to residential site selection? (b) What are the mutual relations between the complex pattern of travel from households and the structure of retail business?
3. A study of the urban, interurban, and national structures of a service industry. Again, structure refers to a spatial layout of the industry in its entirety, and the study treated structural changes as the availability of transportation facilities varies. The question was: How can the pay-off of a transportation improvement be measured? This question was asked for a single industry and pay-off was measured in terms of the industry and of consumers.

In ensuing sections of this paper the contents and questions listed above are elaborated through discussions of the objectives and methods of individual studies. There are implications from these objectives and methods for economic impact research, and these implications will be merged with the individual discussions. It will be noted that the questions asked in studies 1 and 3 could be answered using the points of view and methods of the studies. The questions asked in study 2 proved intractable. The ability or inability to answer questions has implications for impact research. This is given special attention in the final summary of the paper.

STRUCTURE OF RETAIL BUSINESSES

It is well known that the retail businesses of a modern urban area are arrayed in a complex system of locations. The apex of the location system is the central business district, and the grocery on the corner in a residential district and the isolated gasoline station are at other extremes. The availability of transportation makes possible the aggregation of certain establishments serving many customers, thus achieving significant economies of large size and economies from grouping with other establishments. At the same time, many establishments operate effectively while serving only small tributary areas. These businesses may be located in neighborhoods and communities convenient to the ultimate consumer (that is, isolated stores or stores in small shopping centers). At first glance there seems to be an endless variety of location choices available and resulting location patterns. But this is a competitive system. Businesses compete for customers via the transportation network and patterns of business location represent some sort of spatial equilibrium in terms of location choices available, characteristics of businesses, and the availability of transportation and customers.

Effect of Highway Improvements

The highway transportation system is improved; this improvement would set off a game of "musical chairs" with firms shuffling to new locations in their new location environment (Fig. 1). Eventually, a new equilibrium pattern would result. The difference between the before and after pattern is the change induced by highway improvements, and it is the subject under discussion. (After equilibrium will be more efficient than the before if highway improvements are warranted. Efficiencies achieved represent a pay-off from highway investments to retail businesses.) But the game of relocation is much more complex than "musical chiars" because businesses are set within sets and subsets of shopping centers and trading areas. Regional shopping centers are set within the trading areas of central business districts, community centers are set within a higher order network of regional shopping centers, and so on. The many kinds of retail businesses and possibilities for changes in emphasis on goods or services within each business complicate the question as do variations in the time required for firms to respond to changes in their location environments. Again speaking figuratively, one will have a game of "musical chairs" with many players, each playing at his own speed, with his own rules, and having the possibility of going up and down as well as around.

Speaking less figuratively, the structure of retail business mirrors a highly organized and interdependent system of land uses. The environment of the system is the transportation network and customers that may be served over that network. The impact of a highway improvement is in part in terms of freer flows of traffic over the highways (user benefits) and is in part in terms of changed structure of lay-out of the pattern of business (a type of nonuser benefit). It might be mentioned that the retail business problem is one of a set of problems. Changes in the structures of residential, industrial, and other land uses follow highway improvements.

Research was designed to give explicit recognition to the complexity of the location system. First, a study was made to establish the exact character of the spatial structure of business competition. Second, a study was made of the sensitivity of individual elements in the system to changes in available transportation. Finally, the two approaches were brought together to yield a composite analysis of the sensitivity of structure to changes in highway facilities.

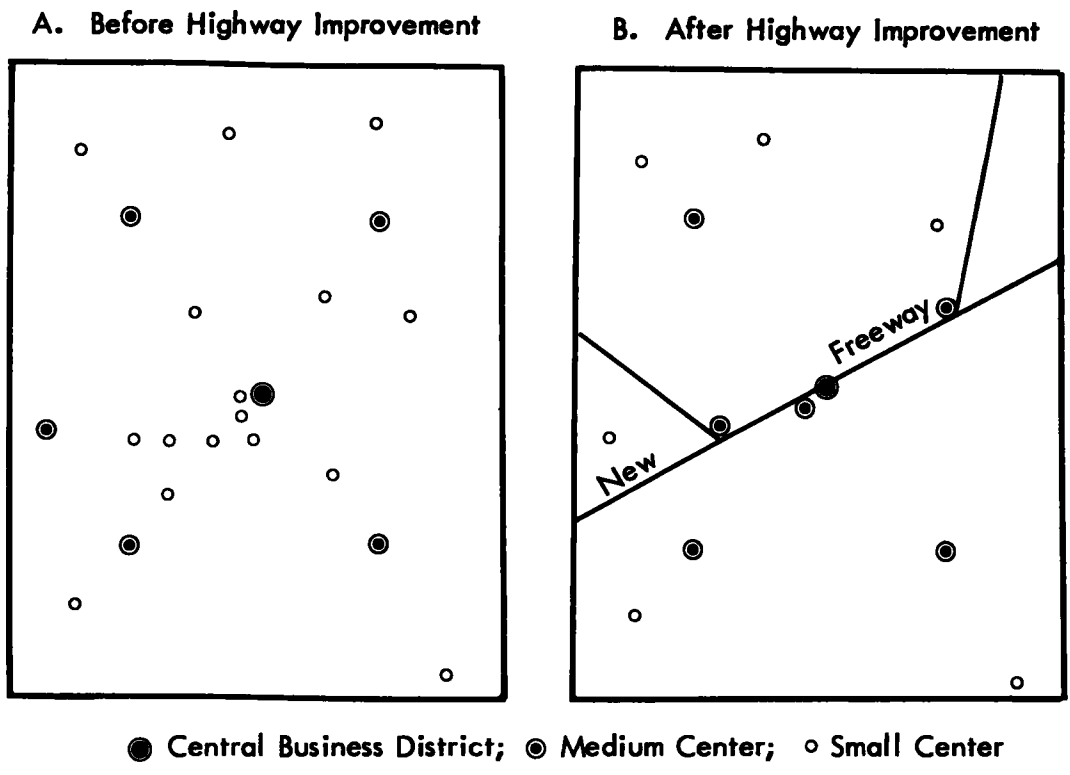

Figure 1. Arrangement of retail business centers before and after highway improvements (hypothetical).

Establishing Structure

The retail structure of urban areas has been analyzed many times and general notions of structure are available in the literature. However, examination of these studies reveals that each uses an a priori classification scheme, details of structure exist by definition and by definition alone. Thus, it was necessary to establish the exact character of the spatial structure of urban businesses.

Detailed data on the location of businesses were available in the case of Spokane, Washington, and in several other comparison areas. The tendency for establishments to associate areally was determined by an ordinary correlation matrix—a correlation coefficient was computed for each pair of businesses in the n locations observed. Next, the tendency for groups to exist was determined by linking correlation coefficients within the correlation matrix. The exact method is too complex to be elaborated here. But it yields business groupings in terms of grouping tendencies and independent of a priori judgments on the nature of groupings.

Finally, continued aggregation using grouping methods yielded systems of nucleated shopping centers and isolated and arterial business locations. Each element in the system was identified as to its composition and as to the strength of spatial associations giving rise to the type. The system included a set of nucleated shopping centers, extending from the isolated grocery store through the central business district. Certain nucleations were also associated with urban arterials including the familiar "automobile row." In addition to these, it was possible to identify a series of highway-oriented businesses of a non-nucleated type.

The validity of the location system identified in Spokane was checked by comparing data from Cedar Rapids, Iowa, Phoenix, Arizona, and Cincinnati, Ohio, and by an examination of data on planned shopping Centers and data on the location of facilities along US 99 in a portion of western Washington.

Sensitivity to Highway Change

The complex business structure identified is subject to change when availability of transportation facilities changes. Just which elements in the system change and in what way is partially evident from variations from place to place in transportation facilities. Another approach to this problem of variations is by examining changes in individual businesses when the highway environment changes over a period of time, and this was the method used to establish sensitivity.

Business sales data were available from a study by Garrison and Marts (2) for establishments in Marysville, Washington, and on a stretch of highway nearby for a period before the construction of a bypass highway around Marysville and a comparison after period. Sales data were also available for a control area which was used to adjust for the influence of general business conditions on the before-and-after data. The problem of observing business sensitivity was quite a complex as that of measuring the spatial system of business land uses. For one thing, the change in highway facilities was more complex than what is implied by simply mentioning a bypass highway. The subject area, Marysville, is on US 99 within a complex of towns and trading areas between Seattle and the Canadian border. The new highway facility decreased congestion in downtown Marysville and also increased the ease of traveling from and to Marysville from other places in the area. This means that the amenity qualities of the business facilities changed as did the competitive position of the businesses versus larger towns and versus other towns which had been competing along the borders of the Marysville trading area.

Other complexities of the analysis included the well-known difficulties of analyzing time series data. Although tax reports on sales were used as the primary data and the data were presumably "good", errors were present. Too, it was necessary to make comparisons with the control area and resolve variations in business classification from one area to the other.

As a result of the study it was found that some businesses had increased in volume of sales, others had decreased and still others remained essentially unchanged. Too, it was found that the seasonality of businesses had varied from the before to after period.

Changes in Structure

Given knowledge of the geographic structure of business activities and knowledge of the sensitivity of individual firms within that structure to highway changes, it was possible to make prognostic statements regarding changes in structure. At the level of technical operations, the temporal analysis was merged with the cross-section analysis, that is, the temporal data were grouped in a manner compatible with the spatial groupings of businesses. Statements could then be made regarding the changes expected in the whole spatial pattern.

But many technical and more general problems could be solved only crudely. In particular, the sensitivity data were restricted to a limited number of types or retail businesses and to the reaction of these types to a particular type of highway change. The rich variation in types of highway changes, retail businesses, and locations that would appear in the course of widespread highway improvements was simply not observed for the observations were fragmentary at best. Another limitation was that the data were strictly short run because only a two-year period after highway improvement was used to compute sensitivity to change. The length of the observation period was not long enough to observe actual business relocations; only changes in business levels were observed. There is no assurance that relocation patterns will correspond exactly to changes in business sales.

On a more general level, there were difficulties in anticipating the pattern of sites available for relocation choices as well as the distributions of markets which might affect these location choices. It was found, for example, that certain of the arterial type businesses were extremely sensitive to changes in highways. However, location choices available to businesses of this type are strictly limited by planning and highway engineering and design policies and procedures. Widespread development of limited-

access highways limits the available sites for such establishments as do zoning ordinances in many urban areas. Nucleated establishments are extremely sensitive to the distribution of households (their markets), and business relocation will depend upon evolving patterns of residential land uses as well as the technical and zoning restrictions on possible location choices mentioned earlier. In other words, it is not known to what degree relocation will be technically possible and to what degree redistributions of customer population will influence the pattern of location choices.

HIGHWAY UTILIZATION FROM RESIDENTIAL SITES

It was just mentioned that questions of the rearrangement of shopping facilities are closely related to problems of the relocation of households subsequent to transportation improvements. The continued development of transportation facilities has seen the dispersion of residences into urban and suburban areas as regular trips over long distances become practicable.

This problem of changes in the arrangements of residential areas could be treated in a manner similar to the approach used in the study of retail businesses. The researcher would establish the present structure of residential areas and, by observing changes in particular parts of the structure, make statements regarding the arrangement of the whole complex of residences following an anticipated highway improvement. Other approaches to the problem were taken, however, in order to experiment with other aspects of impact problems.

Research Questions

During the discussion of retail businesses it was mentioned that a highway improvement occasions a freer flow of traffic as well as a rearrangement of land uses served by that traffic. It is widely known that the purposes and characteristics of travel change, when improved facilities are available. One study of households was concerned with such changes: How does travel from residential sites vary when highways are improved (Fig. 2)? Corollaries to this question are the ways the availability of highway transportation enter into residential site selection and, thus, changes in the structure of residential areas follow highway improvements. In the view of the researchers, these are more penetrating questions than questions that could be answered by observing highway improvements and changes in the structure of residential areas, asking: How does the structure of residential land use change when highways change? That is, the latter identifies how patterns change; the previous question bears more closely on why changes occur.

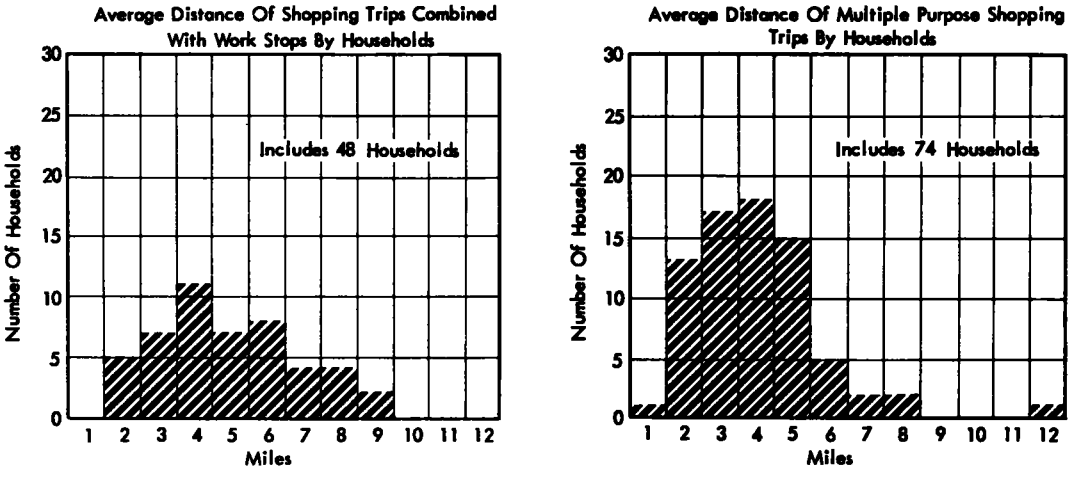

Figure 2. Frequency distributions of average distance traveled by households, Cedar Rapids, 1949.

The problem of the structure of residential areas relates closely to the problem of the structure of retail businesses. In the discussion of retail businesses it was asked how a single system of land uses changes when highways are improved. This simplifies the problem because how retail business land uses change will depend on how other land uses change. Land uses compete with each other for space, and travel is between various types of activities. Stated another way, changes in the structure of residences would occasion changes in the structure of retail businesses. Another aspect of the study of households focused on this question: What are the mutual relations between the structure of residential areas, travel from households, and retail business land uses?

Data Utilized

Data on trips from households in Cedar Rapids, Iowa, were the basic travel information used in the studies. The data were from 30-day travel diaries which were supervised by interviewer contacts every other day through the period of the study. (These basic data were collected by the Traffic Audit Bureau, Inc., and were made available for purposes of the study by that organization and the Outdoor Advertising Corporation of America.) A sub-sample of 100 households was used for expediency in the analysis.

Other data used in the studies were on property values in Spokane, Washington, and Cedar Rapids, Iowa, and the location of retail businesses in each city. Census block statistics were used for property value data, and data on retail business were obtained by field work in Cedar Rapids and from the study of Spokane mentioned in the earlier portion of this paper.

Selection of a Residential Site

A general notion giving direction to the study was that the occupant of a residential site balances cost of his transportation against the cost he must pay for the site at which he resides. The individual who travels a great distance to his residence occupies an inexpensive suburban or rural site. The individual who selects a site convenient to the termini of his trips, and thus keeps travel cost to the minimum, must reside in high rent districts close to the center of town. It is postulated that decreased cost of transportation due to continued highway development will occasion a much greater substitution of transportation cost for site cost. As a consequence, the locations of residences will be widely dispersed in locations where modern transportation facilities are available.

The notion of substitution of transportation cost for site cost was used as a guide to the study of a broader question—a study of how an improved transportation system and easier travel result from transportation improvements, and play their part in changes in structures of activities. One way this broader question was recognized in a study of travel from residential sites was by recognizing the many purposes of travel since travel characteristics may differ by purpose. Travel for department store shopping may not change with improvements of highway facilities, for example, while travel for recreation might change tremendously. These changes would certainly have implications for changes in the structures of these activities.

The research problem stemming from this general notion was to identify the relationships between site cost and travel cost in order to have specific information on the willingness of persons to substitute one for the other.

Several sets of data were examined in two study areas. Each set of data was examined using multiple regression techniques to associate the location of residential sites (within the network of travel connections) with site values.

A study was made in Spokane, Washington, which used simple airline distances from shopping centers as the measure of household location. Information on density of population, racial character, and direction from the central business district were also related to the value of residential sites. The Cedar Rapids study area treated essentially the same problem but variables were weighted by performing a logarithmic transformation upon the regression model. Too, distances were measured in road distance, and the place of work of the head of the household was introduced as a travel parameter.

In each case, census data were used for the value of single family dwelling units, and in Cedar Rapids census data on rents were also processed.

Results varied from model to model, but there was no evidence of strong relationships between the variables studied.

Motivated by the rather weak results achieved by computing the models, supplemental studies were undertaken of the manner in which households utilized transportation. The Cedar Rapids travel data were used for this analysis of characteristics of travel which associated (a) lapsed time away from home, (b) trip frequencies, and (c) total distance traveled with location of the residence (measured in a variety of ways) and a group of socio-economic factors. In all, fourteen independent variates were associated with the three dependent variates (listed above) in three separate studies. Results varied from case to case but, in general, the performance of the models was fair, the models explained roughly half of the observed variations. In the elapsed time and trip frequency studies the socio-economic variables tended to exhibit the greatest associations. In the total distance study the location variables were the most significant. One exception was the variable road distance to the nearest low-order retail center which was significant in the trip frequency study.

Shopping Trips

The Cedar Rapids data on trip characteristics of household were also analyzed from the point of view of the arrangement of retail businesses. The notion here is that individuals travel different distances and at different frequencies for various types of goods and services. The amount of transportation consumed by individual retail business establishments was measured in terms of customer travel to the individual establishments. The shopping center reference points were developed by methods used in the Spokane study of the spatial arrangements of business centers.

The extent of combining purposes of trips was marked—59 percent of the trips studied were for combined purposes. Of the single stop trips, groceries, supermarkets, and theatres accounted for more than half (55 percent). It was found that single-purpose trips were generally shorter than trips for multiple shopping.

It proved extremely difficult to analyze the multi-purpose trips and relate these multi-purpose trips to the complex structure of business centers. An attempt was made to determine groupings of trip purposes but no isolated groups could be developed from the data. Thus it was not possible to construct an ordered grouping of trips which could be compared directly with the ordered groupings of the location of business establishments. As with the other studies of travel from households, it was not possible to establish simple sets of strong relationships.

ANALYSIS OF A SPECIFIC INDUSTRY

One study just discussed embraced the whole complex of retail business and the other the whole complex of travel patterns. The third research approach was through the examination of a particular activity in terms of its spatial layout and travel requirements. This approach merges the approaches of structure and movement. Physician care was studied because of the availability of some reasonably good data. In addition to incorporating concepts from the two studies discussed previously, the physician care study used methods of analysis and points of view which were unique. In particular, the study used a specific measure of the benefits or pay-offs from highway improvements.

It was remarked earlier that highway improvements represent a change in the network of communications over which organizations compete for customers. The act of improving facilities sets off a rearrangement of competing centers and, provided the improvement is warranted, the activity is positioned more favorably after the highway improvement than before. That is to say, improved transportation facilities introduced efficiencies in the activity. Recent history of the physician care activity dramatically illustrates this idea. Prior to the turn of the century most persons were served by physicians nearby or not at all; long distance travel was within the means of a relatively few persons and individuals were restricted in physician care to local non-

specialized physicians. With the introduction of the automobile and the widespread development of paved highways, it became possible for almost anyone to travel a great distance to seek the exact medical care desired. Thus, more transportation was consumed in the process of obtaining medical care, more choices of physicians were available, and physicians could specialize. This resulted in higher quality physician care. To continue to generalize from the example, there were benefits or payoffs to consumers (better medical care), to the transportation industry (more transportation consumed), and to the medical activity (more specialization and more output because the physician could see more patients).

The notion of pay-offs to producers, consumers, and transportation was a guiding notion in the study but, as mentioned earlier, the study complements the studies centering on arrangements of activities and use of transportation by households.

Measuring Pay-Off

A scheme known as the spatial equilibrium model was the organizing device of the study. The spatial equilibrium model answers the following question: Given a set of producers and consumers with each producer and consumer having known supply and demand characteristics and given that consumers are supplied efficiently over a transportation network with known transportation costs, what will be the pattern of production, consumption, and flows if the transportation system is changed? A change in the transportation system may be thought of as the introduction of new routes or a change in transportation cost on existing routes. The spatial equilibrium model also answers the question: What is the value of the change in the transportation network (Fig. 3)? The spatial equilibrium model was applied in three ways in the present study.

In an earlier portion of this study it was emphasized that business activities are set within a complex system of sets and subsets of supply centers and trading areas. It is known that this is the case for medical services. Certain well-known clinics in large urban areas attract patients from great distances, even internationally; within individual regions there are movements at a regional scale; and particular patterns of movements are associated with individual urban centers. No attempt was made to specifically codify the character of the system of physician care centers and trading areas but the existence of such a system was recognized by operating studies of various scales. A national study was undertaken dealing with trade among nine regions. A study on a regional level was undertaken using data for western Pennsylvania, and a study on an urban level was made using data for Seattle, Washington.

Data Utilized

In stating the problems solved by the spatial equilibrium model it was mentioned that supply and demand characteristics as well as transportation costs are given. It was necessary to have information of this sort for each application of the model and, in addition, it was necessary to know the structure within which changes occur and the changes in the transportation network which change structure. Fulfilling these data requirements presented major problems in the analysis.

It is well known that the demand for physician care in a large measure reflects numbers of persons and their disposable income. The ready availability of information on these variables from well-known sources meant that this data could be worked up in a straightforward manner. Physician supply characteristics were approximated by investigating data on physicians' incomes under various conditions and such data are also readily available.

It was necessary to have information bearing on the utilization of the transportation system including cost and patterns of flow between centers of care and tributary areas. Information of this type was available from a study of western Pennsylvania and from the travel data for Cedar Rapids, Iowa, mentioned earlier in this paper. Also, new data were obtained by a study of movements for physician care in Seattle, Washington.

Information requirements on highway facilities prior to highway improvements and changes in cost and arrangements of routes after highway improvements were rather specific. The highway improvements were those of the Interstate Highway System, so

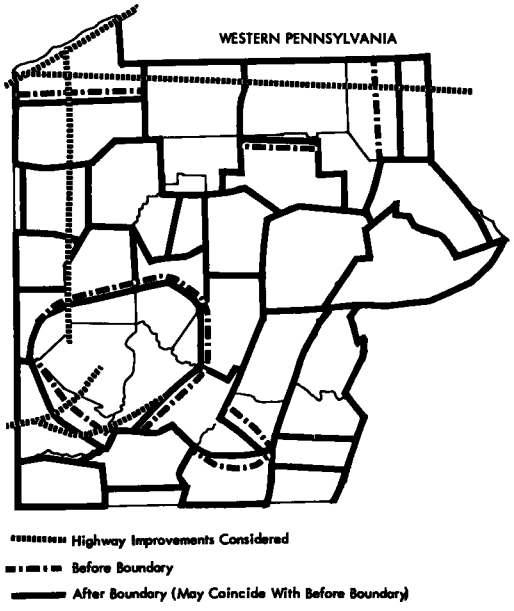

Figure 3. Estimated shifts in boundaries of medical service areas following highway improvements.

anticipated changes in routes were available from planning literature. Materials bearing on cost differentials between facilities of the class of the Interstate Highway System and previous facilities were adapted from prior studies.

The Studies

There were three separate applications of the model—a national nine-region study, a study on a regional level of western Pennsylvania, and a study on an urban level of Seattle, Washington. The national study examined the equilibrium solution for 1950 and made a gross evaluation of the value of having interregional trade. Because there had been no actual observations of movements of persons for care interregionally, and thus little was known about the validity of the operation, no attempt was made to carry the national study through to an evaluation of rearrangements of regional alignments given changes in highway facilities.

A previous study in western Pennsylvania served as the data resource for the intraregional study. A basic solution for 1950 was examined in this case and this solution was compared with projected major changes in highway facilities. Data were restricted to observations on a county level and consequently the analysis was carried through only in a general way for this study area. Too, a rather limited amount of Interstate Highway construction is anticipated for western Pennsylvania, and this limited the magnitude of anticipated effects.

Data in the Seattle study were relatively fine scale in comparison to the two previous studies. Equilibrium models were computed and benefits and losses as the result of planned freeway construction were evaluated.

IMPLICATIONS

Results of the studies have pertinence in a variety of directions. There are, for example, implications for urban and regional planning policies and procedures, policies of highway design and rates of development, and theories of urban growth and development. Although remarks on these points might be interesting, it seems most important to continue to stress implications for further studies of transportation impact problems. The studies reviewed exhibit what can be done now with available ideas and techniques, and also exhibit directions where the exact character of efficient research is obscure. Briefly, successful studies were made of the impact of highway developments on individual activities and on groups of activities. On the other hand, problems of the analysis of transportation from residential sites seem intractable. The ensuing study of research implications will elaborate these brief statements.

Single Industry Studies

In the study of physician care, it was possible to carry the study to a final determination of the impact of highway improvements in terms of producers, consumers, and transportation consumed. The final determinations lacked generality, however, because they were made for one specific urban area and one of many types of highway improvements. Since only one-fifth of one percent of consumer expenditures are for physician care, the analysis lacked generality that might have been achieved if an activity more significant in terms of expenditures had been selected for study.

These problems of lack of generality are by no means insurmountable. More studies are needed for more activities and in more cases. However, analysis difficulties would appear in studies of other activities which would be more formidable than in the study of physician care. It was mentioned earlier that the case of physician care was selected because of data availability. It would be difficult to find other activities where fine scale data are available comparable to those for physician care. Too, the study was facilitated by a number of previous studies on physician care, and it would be difficult to find other industries where comparable levels of information were available. Even in the physician care case, it was necessary to adopt a number of approximate measures in order to operate the study empirically.

The ensemble of data used in the single study included information on highway changes and cost of transportation changes associated therewith. Information from known plans was sufficient to establish changes in highway facilities, but notions of cost associated with new facilities were only fragmentary. Here is another source of error associated with single activity studies.

The use of measurements which are only approximate is especially dangerous. It will never be practicable to study each and every situation, generalizations must be made from specific studies to many cases. Errors which may be relatively minor in a specific instance may become quite significant when projections are made to many cases.

Groups of Activities

The single activity approach fails to single out the interplay of the variety of location forces guiding response to highway changes. That is to say, the study of a single activity neglects the possibility that what is occurring in another activity may affect the studied activity. This problem of the whole complex of activities may be subjected to analysis and this is an important implication of the study of the complex of retail business activities. It has been shown that through a combination of cross-section and temporal classification devices it is possible to make explicit statements of the sensitivity of business structure to highway improvement.

What is needed is a replication of the study of structure in many places and with observations based over a long period of time. Observations of structure at many places would more clearly codify the exact character of the spatial structure subject to analysis. The use of longer periods of analysis would extend experience to cases where actual relocation can be observed.

This is not to say that all that is required is a series of directly repetitive studies. Transfer of interest from retail business structure to some other structure, say the structure of wholesaling, might raise unforeseen problems of analysis. Too, it would be desirable to generalize from the level of a complex of activities of a particular type, say retail business, to more complex situations: that is, the whole structure of activities, recognizing retail businesses, wholesaling, residences, etc., as individual components of structure. Certainly problems will arise at this level of aggregation that have not been experienced before.

Location of Residencies

It was not possible to produce incisive results from manipulations of data relating to travel from residential sites. Thus, the nature of empirical work which will give detailed information on the general problem of the rearrangement of households following highway improvement remains obscure. Useful results are urgently needed. The problems of estimating demand for transportation and thus estimating traffic volumes in light of the relocation of households is central to the whole problem of highway impact and information on how households consume transportation under various conditions is essential to its solution. It should also be mentioned that solution of the problem would enrich the results of researches of the types discussed previously. Problems of the rearrangements of business location, for example, could be solved more precisely if problems of the relocations of households could be solved.

The remarks above should not be taken to mean that no useful work has been done on

the use of transportation from households, for instance, Hall's (4) study of travel in San Diego. A great deal of work has been done with aggregations of households and empirical results on topics such as trip frequency. The problem under discussion here is at a disaggregated level. This point is made clearer in the discussion of the utility matrix to follow.

Lack of results from the research implies that the problem of household travel is an exceedingly complicated one and that fruitful empirical work is not practicable until a better understanding is available of processes that condition travel consumption. This problem is complicated in several ways. One is the analysis of the multi-purpose trip. A large proportion of all trips are multi-purpose and these proved extremely difficult to analyze. Specifically, it was not possible to relate patterns of multi-purpose trips to either spatial patterns of business land uses or the makeup of households generating the traffic.

A Suggestion

Inability to make incisive statements regarding travel from residential sites indicates that travel decisions are much more complex than relatively naive models will reveal. From discussions with others and the review of research (Marble (5)) it may be suggested that two elements should be introduced into the models. The first is measure of the utility of travel as such to the traveler. Previous models have treated travel as a phenomenon to be minimized while achieving gains at destinations. Perhaps one should think of maximizing joint gains from travel as such and gains at destinations, subject to limitations on the amount of travel that is regarded as desirable, and the like. The second is that the traveler has imperfect information regarding the outcomes resulting from travel.

These two notions may be explained rather crudely in a table (Table 1). There are n households and m destinations. Associated with each household and each destination is a utility of the trip, u_{ij}. Household 1 assigns the utility u_{11} to destination 1, for example.

It is easy to see why statements about individual households are extremely difficult. Associated with the household is a vector of trip utilities, $u_{i1}, u_{i2}, \ldots, u_{im}$, from the utility matrix and knowledge of the elements in this vector is needed. But these elements are not fixed numbers. Take the case of shopping destinations, for example. Prices, goods available, and services at individual destinations change from time to time and the traveler lacks perfect information on these. Thus, the household is choosing in light of probabilities of the utility of trips, and utility assignments would change from time to time as well as from member to member of the household. Too, in associating characteristics such as trips made by households with a destination (examining a column) it must be recalled that households are at varying locations and, consequently, are reacting to their vector of utilities in varying ways. In this sense, the average of a characteristic, such as average trip length, is by no means necessarily related to some summary measure of the utilities, such as average utility.

The discussion in the paragraph just completed emphasizes the value to the traveler of reaching the destination. There is also value attached to the act of making the trip. Thus, the elements u_{ij} in the utility matrix may be separated into a u^*_{ij}, which is the value of being at the destination, and a u'_{ij}, which is the value of making the trip ($u^*_{ij} + u'_{ij} = u_{ij}$). As was true of the value of achieving the destination, the value of making the trip, u'_{ij}, would vary from time to time since congestion, weather, etc., vary from time to time. The traveler would have imperfect knowledge of the state of these factors, so the u'_{ij} are not fixed and known numbers.

Predictions of Trips from Residential Sites

A significant body of information has been obtained by measuring amounts of travel, for example, trip frequencies. But this information is of questionable value in projecting characteristics of travel following highway improvements since it only indicates to what extent the desire to travel results in travel, given present travel facilities. A change in travel facilities will result in a changed amount of travel. But knowledge of

TABLE 1

MATRIX OF TRAVEL UTILITIES

Households \ Destinations	1	2	3			m
1	u_{11}	u_{12}	.	.	.	
2	u_{21}	.	.			
3	.					
4	.					
.					u_{ij}	
.						
.						
n						

this change is limited since there is no direct information on relationships between travel characteristics and travel desires.

Estimation of travel characteristics in terms of the utility matrix poses a major problem to the researcher. But estimation can only follow exact statement about the matrix to be estimated, and discovery of empirical devices powerful enough for that estimation. This is a major problem and a major challenge to the highway transportation analyst.

SUMMARY

Experience indicates that useful studies may be made of the impact of highway improvements on single industries and on groups of industries. Studies of household travel in relation to highway improvements which centered in travel to retail business location and changes in travel characteristics, were of limited success. Lack of success suggests that household travel characteristics are much more complex than the simple models used to approximate travel characteristics indicate.

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Some Effects of Limited Access Highways on Adjacent Land Use

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● RECENT progress in state and interstate highway planning has placed increasing emphasis on the theory that the generation and distribution of traffic is a function of land use (1). Everyone familiar with transportation development knows the validity of the reciprocal theory—that land use is a function of traffic facilities.

The purpose of this paper is to examine the application of this theory to the limited access highways built through suburban areas under the new Interstate Highway System program. For present purposes suburban areas are considered as extending 30 to 40 miles from the centers of major cities and somewhat shorter distances from cities down to about 50,000 population. For convenience a limited access highway is called a freeway; this means a highway that has no access to adjacent property except at grade-separated crossings, called interchanges. (In a few cases there may be interchanges at grade.)

It is considered that the suburban land uses resulting from freeways will be more extensive and more competitive than is generally realized; that these land uses will generate new traffic of unpredictable volume; that unless they are adequately controlled they will impair the usefulness of the highway system and cause serious economic loss to local communities and their citizens.

Fortune Magazine (2) observes that Americans seem to regard the expanded national highway program merely as an impressive engineering feat, which they hope will finally clear up the traffic mess. As Fortune points out, "the program is going to affect the economy and the whole pattern of development in our metropolitan regions.... But the program is being guided primarily in engineering terms, and so far there has not been enough coordination between the highway departments and the other interests that will be so vitally affected."

The types and patterns of adjacent land use created by freeways are quite different from the strip developments that occur along major highways with continuous access. In the latter case the prevailing uses are retail stores and local shopping centers, motels, bars, restaurants, real estate and insurance offices, used car lots, and service stations. Some of these establishments serve their local communities; some are chiefly dependent on highway traffic. When such a thoroughfare is replaced by a freeway the proprietors of these establishments are sometimes told that their interests will be served by "frontage roads" affording unimpaired visibility to the passing traffic, which can reach them from the nearest turn-off.

If California's two-decade experience with freeways is pertinent, these frontage roads do not quite fulfill this function. Passing a small establishment at a 60 mile speed, the motorist gets only a flash glimpse of it on his right hand; if it is on the left-hand frontage road it is almost beyond the range of his normal vision. Furthermore, the motorist has learned that if he turns back to reach a frontage road establishment he will get involved in a labyrinth of lanes through which he will be lucky to win his way to the spot he is seeking. Frontage roads are costly facilities at best, since they serve land uses on only one side, and they create difficult design problems at interchanges (3).

FREEWAYS ATTRACT TWELVE TYPES OF LAND USE

Although small commercial establishments have found it difficult to take advantage of freeway locations, the freeways are drawing to their flanks a dozen specific types of larger-scale land uses as follows:

1. Residential subdivisions and garden apartments.

2. Regional shopping centers and major regional stores.
3. Manufacturing plants and industrial parks.
4. Distribution warehouses, truck terminals, and area sales offices.
5. Bowling alleys, skating rinks, night spots, drive-in theatres, and other amusement centers.
6. Large motels.
7. Central office buildings for insurance, utility, and other companies.
8. Service stations and eating places.
9. Hospitals, churches, and other institutions.
10. Auction yards, farm equipment and used car sales lots.
11. Trailer parks.
12. Private and public airports.

Although all these land uses have long been highway-oriented, they suddenly expand in scale when they seek locations along a freeway. This is because of the increased potentials created for them by one or more of the following functions that a freeway performs to a much greater degree than an ordinary highway:

1. It provides quick access to other parts of the adjacent urban area.
2. It collects labor from a much wider area, bringing workers in all weathers from homes 30 to 50 miles distant.
3. It collects customers, clients, pupils, and spectators from even greater distances.
4. It collects and distributes supplies and products over a greatly extended range; the "overnight delivery" radius may be 400 miles.
5. It is an advertising channel of enormous volume and penetration.

Whereas it is obvious that all these functions attract the land uses in question to the vicinity of a freeway, the fifth function attracts them to sites adjacent to the freeway. Every one of the land uses that have been described wants to be visible to the freeway traveler. A single store on a frontage road gets only a split-second flash of attention, but a major establishment sited at the top of a long rise, at the foot of a decline, or in the hollow of a curve, has an "exposure" that is tremendous.

PROPER LOCAL ROAD DESIGN CAN PROVIDE ADEQUATE SITES

All these land uses, as already noted, require much larger sites on a freeway than they occupied on full access highways, and they require sites as near as possible to interchanges. To accommodate them adequately, a well designed local circulation system will provide, instead of a frontage road, a major street paralleling the freeway at a distance of 300 to 600 ft extending from the interchange as far as may be needed. This will afford space for establishments to back up against the freeway, with convenient access to it through the interchange and with full benefit of the freeway's advertising value. For service stations, drive-ins, and other freeway-related businesses, frontage roads may sometimes be necessary, but unless they are controlled by proper zoning they can develop new strips of blight. One frontage road on the San Bernardino freeway displays the following land uses in this order: (a) service station, (b) coffee shop, (c) junk yard, (d) motel, (e) trailer court, (f) bar, (g) grocery store, (h) shoe repair shop, (i) vacant building, (j) state highway patrol office, (k) three vacant buildings, (l) state employment office, (m) nursery school and (n) church.

But the land use that wants a freeway location most, and usually gets there first, is the residential subdivision. The subdivider is eager for the freeway traveler to know that Sunrise Ridge or Sunset Acres is just 20 minutes from the city or 5 minutes from the airport—"if you lived here you would be home now." He knows, too, that many people apparently like to live within sight, sound, and smell of the teeming freeway (4).

The subdivider who preempts a quarter mile of a freeway border and a quarter mile on both sides of an interchange cross-road will usually fasten a low-tax-revenue, high-traffic-hazard pattern on the area permanently. Not only do most subdivisions produce more local service costs than tax revenues, but they discourage the development of higher revenue land uses in their vicinity. Home dwellers who may like to watch freeway

traffic from behind a wire fence will strenuously object to having part of that traffic pass through their local streets, where their children play, enroute from the freeway interchange to a nearby industrial plant or a shopping or amusement center. The chances are, too, that a school will be close by to further inhibit traffic movement.

The subdivider gets a tangible benefit from freeway "exposure" in the promotional stage of his project, but the dweller in one of his houses does not get any tangible benefit. Thus the temporary advantage of one freeway-bordering land use results in the exclusion of other uses which could enjoy substantial permanent benefits.

Obviously the "highest and best use" of land in the vicinity of a suburban interchange would include freeway-related service establishments on the most accessible sites, larger freeway-oriented developments, commercial and industrial, in locations close to the interchange, and residential areas beyond. This is the pattern that creates maximum convenience, maximum land values, and maximum tax revenues. Combined with a well designed local road system it provides efficient movement of traffic between the freeway and the developments along its borders.

A good example of this kind of orderly development may be seen around the Valley Forge Interchange at the junction of the Schuylkill Expressway and the Pennsylvania Turnpike 15 miles northwest of Philadelphia. Here in a former farm area the supervisors of Upper Merion Township have created by careful zoning a logical pattern of commercial, industrial, and residential land uses (5).

LOCAL LAND USE CONTROLS ARE ESSENTIAL

But such a desirable pattern will only develop where the land surrounding an interchange is controlled by a single owner who understands its best use, or where local government, as in the case of Upper Merion Township, has a comprehensive plan implemented by precise zoning and adequate local road standards. Within the major incorporated cities this kind of planning can reasonably be expected; outside such corporate limits it seldom now exists (6).

State highway officials recognize that counties and townships, as well as cities, must engage in community planning if the new highways are to be protected against adverse use of adjacent land. Pennsylvania's Deputy Secretary of Highways, Carl W. Wild, said in a recent address that local planning and zoning are particularly necessary along the Federal Interstate System. "The interchange locations will present opportunities for well-planned commercial and other uses, or for the most chaotic development we have ever seen," he said. "The decision will be local." (7)

In urging counties, townships, and other local jurisdictions to meet the situation by appropriate action, the state and federal highway builders, the highway users, and the local citizens all have a common interest.

While the highway builders are not responsible for local planning, they are vitally concerned with it because new developments along the right-of-way will generate large and unpredictable volumes of freeway traffic. This can result not only in early overcapacity loading of the freeway itself, but ramps and interchanges may be seriously congested (8). A classic example is the Santa Ana Freeway southwest of Los Angeles on which, in addition to many new subdivisions, three large-scale traffic generators have been located in close proximity to each other—Disneyland, Knott's Ghost Town, and the Anaheim Shopping Center.

On a highway that is being converted to a freeway west of St. Louis the writer was recently stopped for nearly 15 minutes by several hundred homeward-bound cars of construction workers entering the highway from a huge new Chrysler plant that will employ several thousand men, all of whom will drive to work. Fortunately this development has occurred before the completion of the freeway, so that a proper interchange with adequate feeder lanes can be provided at this point.

When large industrial plants or amusement centers are located at intervals along a freeway their peak-hour traffic can move more readily than when they are heavily concentrated near a single interchange. When land is zoned for specific uses in logical and realistic relationship to freeway facilities, it is possible to estimate within some broad limits the new traffic volumes that will probably be generated.

The concept of comprehensive land use planning is new to most county and township governments in suburban areas. Many studies are being made of zoning and other devices for land use control, including the acquisition of easements, development rights, and wider rights-of-way on interchange approach roads. These studies are of basic importance to the success of the highway program.

One suggestion that appears to have considerable merit is to have the state highway commission or other state agency empowered to do the zoning job in critical areas bordering highways in case the county or township fails to act (9). This would of course involve the setting of some standards by the state for acceptable zoning patterns along state and federal highway—a logical recognition that such protection is essential if the highways are to serve the public purpose for which they are built—namely the safe and rapid movement of motor traffic.

It is not to be expected that a state highway commission would devise zoning standards for an extended area surrounding an interchange, as the Upper Merion Township Board did in the case just mentioned, though a state planning agency might do so. A highway commission's direct concern would be limited to assuring approach roads of proper width, unobstructed by the traffic of industrial, commercial or other establishments close to the freeway ramps.

To freeway users, land use planning as an accompaniment to freeway building is a matter of concern for obvious reasons. Their benefits of safe and rapid movement are in jeopardy if traffic bottlenecks develop through the overloading of off-ramps, congestion on interchange approach roads, or similar causes.

Land use planning is likewise of vital concern to local governments and citizens, since the uncontrolled development of land uses can not only impair property values and tax revenues but can lead to excessive costs in providing all types of local public services. If a freeway separates a sewage treatment plant, for example, from an area that is going to be intensively developed, foresight would dictate the laying of a sewer main beneath the freeway at the time it is built. Similarly, thought must be given to the location of schools, fire stations, parks, and many other local facilities.

"The new expressways are being located," say Harold M. Mayer, of the University of Chicago, "primarily with reference to their ability to move vehicular traffic. That is their function. But too little thought is being given to the relationships of the routes to the present and future patterns of commercial, industrial, and residential areas they serve." (10)

MANY PUBLIC AND PRIVATE INTERESTS ARE INVOLVED

While land use planning and zoning are immediate means by which the interests of highway builders, highway users, and local citizens may best be served, it is evident that the problems to be met will involve many agencies of local government and private groups as well. Districts or departments of recreation, public safety, transit, urban renewal, water and power, will all be directly involved in addition to the agencies that have already been mentioned (11). Marine terminals and airports, where they exist, will also be concerned with land uses bordering on the freeways. The railroads' interests were early recognized and helpful working relations between them and the highway builders have been established in most states. The annexation of suburban areas to incorporated cities, and the creation of new cities and towns, will be among the other developments that freeways will drastically affect.

This paper has dealt only with freeways built in suburban areas, where the problems of regulating adjacent land use are most numerous and acute. Similar problems will arise, though probably in lesser degree, in many rural areas. Implicit in all these problems is the effect of freeways on adjacent land value, which is the subject of many current studies that should produce a large amount of helpful data.

Meanwhile it seems evident that federal and state highway commissions will need to develop, on a voluntary or an official basis, relations with local municipal, township, and county groups to urge upon them the necessity for constructive action on the land use control problems in view. Such relationships should result in more realistic benefit-cost analyses, more useful freeway design, and more assurance that the freeways will serve their intended purpose.

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The Land Use Map Versus the Land Value Map—A Dichotomy?

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● CHANGES in land use and in land value are major variables in all studies of the economic impact of highway development. They are in most cases determinant, and they lend themselves to objective measurement. For these reasons there is a recent notable increase in the volume of economic research reports that deal with these twin variables.

Studies with this focus are not new; land use and land value investigations have been the staple product of research in the fields of land economics and geography for many decades. In spite of this history, there is a disturbing lack of precision in current efforts to measure the impact of highway programs by tracing changes in land use and value. This paper reports one effort to refine concepts of use and value change, and to sharpen the methodological tools by which their measurement is attempted.

One of the major consequences of a change in the quantitative or qualitative level of highway services is to be found in the changes in land use that can be attributed to highway improvement. These use changes, in turn, create a base for and are foreshadowed by changes in land value. The major focus of this paper is on the sequence in which these associative land use and value changes occur in time, and on the patterns which they form in space.

Land use and value changes are constantly occurring and will continue to occur, whether or not an overt change is made in the existing level of highway services. The research worker is never able to conclude that the changes associated with the improvement of a highway facility are therefore to be attributed to that improvement. He is always faced with the prospect that they might have occurred anyway. In this setting the burden of proof rests upon any assertion that observed changes in levels of land value or intensities of land use are to be attributed to known changes in the availability of highway transportation. One of the major hypotheses underlying this paper is that land use and value changes associated with highway change are not necessarily to be attributed to it, and that the preponderance of argument must be great before causal relationships can be validly inferred.

A second assumption is that the time sequence in which these changes occur is highly important. In a market economy, changes in land use are foreshadowed by changes in its value even though the nature of the use of land ultimately creates the base for its value. That value is typically imputed to the land ahead of (and often far ahead of) the time at which the exercise of these new uses becomes economic reality. To use existing land value levels as a measure of the economic impact of a highway improvement is therefore an untenable procedure until something is known about the lag that exists between anticipatory value increases and ultimate use changes. Where this lag is great, the effect of highway improvement can be to force land into idleness, devoted to no economic activity other than that involved in the waiting process.

Another reason for attributing high significance to the time sequence relates to the element of abruptness of the decisions and the responsiveness of the market as choice is exercised among the alternative uses of land. An upsurge of residential demand can push meandering tentacles of urban development far out into rural areas. In these circumstances, values often tend to be overstated in total, and their relative distribution with respect to the altered use pattern can be seriously misleading. Mistaking the effects of abnormal market conditions for the effects of highway improvements must be avoided. To sharpen the distinction between these effects requires something more than the net changes or results detected in a "before and after" study. The time sequence, rate and duration of the elements of change must be interpreted "in process", to gain the needed perspective.

Almost all studies of the impact of highway development begin with an unstated assumption that the ultimate effect of better roads is higher land values and more intensive land use. There is massive historical evidence to support this assumption,

and in global terms there is little reason to question its general validity. The development of new types of limited access highways requires re-examination of this hypothesis regarding the value-appreciating consequences of highway development.

Accessibility is the key to land value and land use. Where accessibility is impaired to any degree it may not be valid to assume a linear relation between land value, land use, and highway development. The system of interstate highways to be constructed under the Expanded Federal Aid Highway Act of 1956 will bring about a basic change in old patterns and forms of accessibility. Land uses directly abutting the Interstate System will often have access by means of service roads, whereas in the past access to the older highways would have been direct from any abutting property. This does not necessarily imply that access has been impaired, but in many cases the nature of the access to the highway will have been substantially altered. By separating local from through traffic, the nature of access to certain forms of land use may actually be improved, although direct access from abutting properties may be limited or precluded. Considerations of this nature call for a careful study of the relations between land value and land use as they are affected by proximity to the highway, access to the highway, situation with regard to major interchanges or crossovers, and relation with the pattern of service and access roads. The tasks of measurement in this setting will demand a relatively high degree of refinement and precision in any techniques developed to measure use and value changes.

There is another unstated assumption that an increase in the level of highway services will enhance the value of land in any given use. If a farm once located in a dirt road is now served with a gravel road, it has been customary to regard this as a value-enhancing factor. When the level of road service is improved further, and access to market is provided over an all-weather road, an additional value increment is appropriately inferred. These value-enhancing effects, and the observations supporting them, have been appropriate to a developing economy in which the level of highway services had failed to keep pace with the demand.

With the continuing improvement of highway networks in rural and urban areas a possibility arises that in some areas the highway network may be approaching a level that can be considered adequate for certain existing patterns of land use. If this condition prevails, further development in the highway network may be of limited value to the adjacent lands, in their present uses. If the existing roads and streets in a residential subdivision are satisfactory for residential traffic needs, additional highway developments may not lead to more intensive uses or higher values associated with residential use but may require major changes in land use to permit their realization. Similarly, if all farms in an area are on hard surfaced, all weather, snow plowed roads, the addition of more traffic lanes or of superior engineering features may exercise little influence on the value of adjacent lands if they remain in agricultural use. The value enhancing forces associated with highway development at this level may require a change in existing use patterns to permit their realization.

This argument suggests that land value and land use changes associated with highway development may be divided for purposes of analysis into two classes:

1. Economic impacts that are observed within major use classes. These might be termed "intra-use class changes."
2. Economic impacts that are observed to occur only when there are major changes in land use. These may be termed "inter-use class changes."

In examining economic impact in terms of either of these classes, highways may affect both the level of total values and the relative distribution among locations or uses.

It is apparent that the major impact of highway development is to be observed in connection with shifts of land among major classes of use, that is, the inter-use class changes. Put in other terms, increases in land value or in the intensity of land use associated with a given highway improvement are of less significance if the land use remains the same than if the class of use changes. Among agricultural uses, some value increases can be observed to relate to improvements in the highway network. After a certain level is reached, if additional increases occur they are likely to reflect a new level of values associated with a shift to residential, commercial or urban use.

These observations have led to the heaviest concentration, in this study, on the economic impact of highway development as it is manifest at the "hinges" linking major classes of land use. It is at these margins of transfer among major use classes that the critical impact of highway development is most clearly discernible.

The argument to this point can be summarized as follows: Because of the limited access feature of the new interstate freeways, it will be necessary to pin-point the study and measurement of any consequent changes in land values. This will require greater precision in land value determination than has been necessary in the past.

Similarly, because the new highway program is being superimposed upon an existing and well-developed network of roads and highways, it can be anticipated that the major consequences of the new system will be reflected in shifts in land use, rather than in the intensification of existing uses. For this reason it will be necessary to develop concepts and definitions of land use, and use changes, that can be determined objectively and that relate to relatively small areas of land. Without this precision, the treatment of land use will be confined to description alone, and it will have little value as an analytical tool.

In this connection, one can identify two kinds of variation in land use:

1. Those that can be detected by aerial photographs or by field study; the "visible changes."
2. Those changes that involve a shift in intensity of use without resulting in a change in major use classification or in the proportion of the total area covered with structures. These are the "invisible changes" that may be relfected in data on the dollar volume of business transacted, or in other measures of the "flow" of economic activity.

Paralleling these use changes, there are also two types of change in land values:

1. The realized changes, that occur when properties are sold and that can be more or less accurately determined by reference to a market process.
2. The latent or unrealized changes that may have taken place but as yet are unreported in any market transaction and thus must be inferred from market sales of similar properties, if any, or imputed to the property through some subjective process of appraisal or assessment.

The collection of data on land use has been greatly simplified in recent years through the process of aerial photography. With the development of procedures for spot field checking of the aerial photographs, a technique is available that makes it economically feasible to conduct repeated land use surveys by aerial means as frequent time intervals. Systematic data of this nature, at intervals of one or two years, are now available for a number of urban areas and major highway routes.

One of the innovations attempted in this study has been the development of a uniform grid for the classification and mapping of land uses. In open country this grid has usually been the square mile or the quarter section (160 acres). In suburban areas, land use grids of 40 acres and of eight city blocks have been used with success. By relating land use to a grid system the analysis of land use changes over time is greatly facilitated. An additional advantage, of importance in the study of large areas, lies in the fact that land uses related to a grid structure lend themselves to analysis through machine tabulation and mass-data techniques.

The collection of land value data has experienced no similar technological revolution. It is still a laborious, expensive, and time-consuming process. It is further complicated by the small number of properties changing hands in any one year. Referring to the types of use and value changes enumerated above, the bulk of the important use changes are "visible" changes and can be studied by means of aerial photographs. The major part of land value changes (in an areal sense) are the latent or unrealized changes that have not been reflected in the market place or through a commercial sale.

In this setting, it is pertinent to explore the possibilities of developing a measure of changes in the levels or configuration of land values by inferring them from observed land use changes. If dependable relationships can be found that link land values to land use, in either an ordinal or cardinal sense, a long step forward will have been taken in the attempt to identify and measure the economic impact of highway development.

With this formulation of the problem two difficulties emerge. One involves the refinement of land use classifications to render them operational for analytical purposes. Traditional land use classes are broad, functional designations involving concepts of major use types designated as agricultural, residential, commercial, industrial, etc. Those classes are too broad for use with any acceptable degree of precision. The first step in refining these broad use classes has involved the determination of the extent to which given units of area are "covered" by structures. The extent of the "coverage" and the uses to which the structures are put can be determined from aerial photographs, with verification by field reconnaissance.

The designations as to use and the size of the use areas are transferred to plat maps showing ownership or parcel boundaries. From these data the use maps are drawn showing the percentage of land in each use in the "covered" areas and in the "uncovered" areas. Uses in the covered area include residential (urban, rural, etc.), commercial (neighborhood grocery, shopping center, filling station, etc.), industrial, and institutional (school, church, road, street, etc.). Uses in the uncovered areas include farm (or idle rural), idle development (awaiting residential, commercial, industrial or institutional development), auxiliary commercial (storage, parking, outside display space, etc.) and auxiliary industrial (factory parking lots, loading areas, etc.).

At this level of refinement the land use classes are still too crude to permit any close relationship with land values. The next step in refinement has involved a rearrangement of use-class boundaries on the basis of the characteristics of the individual properties: floor space, type of structure, function to which it is put, etc. Land use classes thus refined, when incorporated into the grid system of analysis, have shown promise of yielding systematic relationships with land value.

A critical area in the application of this procedure of land use mapping involves the suburban fringe where the surface is only partially covered with residences. If the residential area is fully built up, with lots of conventional size, there is no serious problem. If lot sizes range from one-half to ten acres or more, three possibilities exist:

1. The area may be an exclusive residential district, of expensive homes on large lots, and in that case can be regarded as fully covered for that class of use.
2. The area may experience further residential subdivision and thus reflect a highly undeveloped or uncovered status, at the time of survey.
3. The area may experience further subdivision with major changes in use, to commercial, industrial, etc.

Where the pattern of current use comprises islands of land with a high percent of covered area, interspersed among large areas of open land, the process of land use classification needs to be repeated at frequent time intervals to yield useful results. In a dynamic market economy typified by unplanned urban expansion, this problem is inherent in the situation. It is unfortunately true that some of the greatest difficulties in relating land use to land values can be expected in the areas receiving the full force of anticipatory or developmental urban-growth pressures.

The mapping of landuses is an established procedure and the results are readily understood. Land value mapping is a relatively uncommon analytical device. Where it has been attempted in the past it has usually been confined to large units of area, often of the size of a county and rarely ever smaller than a civil township. Units of this size are much too large for analytical purposes.

In order to reduce land value data to a form that will permit the study of their association with land use it is necessary to express them in terms of an appropriate grid. As described above, the grids used have been the section or quarter-section, in open country, and tracts of 40 acres or eight city blocks, in urban areas.

Two problems emerge in an attempt to develop a usable grid pattern of land values:

1. In any small area, for example a tract of 40 acres, or one of 8 city blocks, there are too few market transfers of real property to permit a dependable reference to market price in determining value. The pattern of values must often be inferred from sales in an earlier time period or from those of similar properties outside the unit area.

2. The market rarely establishes values for land that are separate from the value of buildings or improvements on the land. The subjective element in any attempt to map land values alone is so great that the results are of little use. This fact forces attention upon the composite value of the land with its appurtenant improvements.

Although it would be possible to rely on the process of appraisal to determine the value of properties in small areal units, the cost would be prohibitive. The only readily available data on property values by small areal units or ownership tracts are those placed on the tracts by the property tax assessors. From many studies of the relation between property tax assessments and market prices one knows that the reliability of assessors' data is seriously impaired. Properties of low value are frequently over-assessed relative to higher-priced properties; large and complex properties are typically undervalued compared to smaller ones. Assessment data commonly lag behind market values, and are sometimes unchanged for years on end. These characteristics preclude the direct use of assessors' valuations.

In spite of these defects, the possibility remains that assessment values may be useful if some systematic relation can be discovered between assessing practices and market prices. One procedure that has met with some success involves the calculation of the ratios of the assessed value of the land to the assessed value of structures on the land, for each property involved in a market sale. This "building/land" ratio is commonly less than one for rural lands (assessed value of improvements are well below the assessed value of the land), and greater than one for urban properties. In urban, suburban, and rural residential areas an array of these ratios for properties that have been sold in recent years has disclosed a substantially linear and positive relation between the size of the ratio and the market price of the property.

In other words, although assessed values are not systematically related to market price, it has been found that in certain urban and suburban uses the ratios of building assessments to land assessments provide a reasonably satisfactory base for estimating market values.

With the use of the building/land ratio, it has been possible to estimate market values from assessors' data, for all ownership (or assessment) tracts, in spite of the fact that very few properties have actually been sold in any given time period.

From the network of estimated values thus determined it is a simple matter to reduce the tract values to estimates of value per unit area. In rural areas the grid selected has usually been one square mile, or one-quarter square mile (160 acres), depending upon the size of the ownership parcels. In urban areas a grid of eight city blocks or 40 acres has been found suitable for most purposes.

With property values (land plus structures) available on a grid of area units it is then possible to construct "area-value" maps of the "relief" or topography of values and to evaluate the degree of coincidence, or spatial association, between patterns of use and value. This is important; for the two patterns must be closely associated geographically if it is to be possible to explain or predict value impact rationally on the basis of use changes. From examination of the small number of maps thus far prepared, the spatial association of use and value is quite clear in general but rather poor in detail. The imperfect association is believed to be the result of inadequacies in estimating area value, and even more, in the classification of types of land use. Land use classification requires more categories and, probably, some different concepts, than those which are now commonly used for planning studies. Furthermore, it remains to be demonstrated to what extent even the general spatial association which exists between patterns of use and value will hold through time. These are questions which can be answered only through continued study.

It should be noted, however, that the maps prepared to date have shown a high correspondence between grid-squares of high land use intensity and grid-squares of high land values. In maps prepared for three townships in Washington county, adjacent to the city of St. Paul, Minn., ten of the twelve "highs" are centered in identical grid squares on the land use intensity and land value maps; the other two are within half a mile of identical positions. Although further improvement in use classification and value determination procedures is needed, the data support a tentative conclusion that

land use and land value can be treated analytically as two branches from the same stem of economic relationships.

On the basis of work accomplished to date it is possible to indicate some of the uses to which these techniques of measurement may be put. With the explosive development of cities, and the radical amendment to highway network through the Interstate System, one will witness the development of an entirely new topography of land and property values. It is as if some gigantic economic upheaval were thrusting up new mountain peaks and creating new valleys and escarpments of land values in what once had been a comparatively flat and featureless plain. To continue the analogy, one can also detect the appearance of economic fault-lines in the value structure and can note the appearance of areas where values are eroding away.

These changes can be more readily identified if one can develop a systematic procedure for "area-value" mapping, in a time sequence. Time is the important element in this problem. What changes first occur, following a highway development? In what order can subsequent changes be expected to take place? It is admittedly impossible to develop perfect knowledge regarding the impact of forthcoming highway improvements. The hope remains that land owners, city planners, tax authorities and the general public can be given better indicators of the scope and nature of the impending changes that the new highway program will bring.

The generalized effect of these changes can already be anticipated. The effect of better transportation is to increase the availability of land for any given use or user. Lands once disadvantaged are rendered more valuable. The lands distant from an urban core are appreciated in value relative to lands at the center.

In this framework, there can be detected a flattening-out in the gradient of land values as one follows radial lines away from central business districts. The network of urban property values is spread over a much wider area. The net effect is to depreciate site values and the monopoly element in location. In commercial and business uses, the front-foot value of land seems likely to depreciate relative to square-foot values. In a more massive fashion, the importance of land serving retailing, residential and recreational needs increases relative to the importance of the land required to provide food.

Better highways intensify these trends. It is all the more necessary that there be developed techniques of study and measurement that will permit one to include the total structure of land uses and values within his frame of reference. Paul F. Wendt, in a recent article remarked that: "...One of the first steps necessary to further analysis of the changing structure of urban land values appears to be the development of accurate land use information portraying the increments to the supply of urban land over time and the assessed values adjusted to market value of the major classifications of urban land." (1)

The techniques of land use and land value mapping described in this paper are offered as one possible answer to the felt need that Wendt has aptly stated.

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REFERENCE

1. "Economic Growth and Urban Land Values." The Appraisal Journal, p. 443, (July 1958).

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The HIGHWAY RESEARCH BOARD was organized November 11, 1920, as an agency of the Division of Engineering and Industrial Research, one of the eight functional divisions of the NATIONAL RESEARCH COUNCIL. The BOARD is a cooperative organization of the highway technologists of America operating under the auspices of the ACADEMY–COUNCIL and with the support of the several highway departments, the Bureau of Public Roads, and many other organizations interested in the development of highway transportation. The purposes of the BOARD are to encourage research and to provide a national clearinghouse and correlation service for research activities and information on highway administration and technology.